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USSR Report

ENGINEERING AND EQUIPMENT

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USSR REPORT

ENGINEERING AND EQUIPMENT

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AERONAUTICAL AND SPACE

NUMBER OF IMPULSES FOR MINIMUM-ENERGY FLIGHT BETWEEN NEAR KEPLERIAN ORBITS

[Article by S.N. Kirpichnikov and V.F. Baykov]

[Abstract] Optimization of interorbital flight between Keplerian elliptical orbits sufficiently close to one another by means of impulsive maneuver is considered, for which the problem of determining the maximum number of impulses as function of the orbit eccentricity for minimum-energy flight is solved by synthesis of the optimum control on the basis of Pontryagin's maximum principle. This principle is formulated for the Euler equations of motion along osculating orbit elements and differentiation with respect to the characteristic maneuver speed divided by the gravitation parameter as new variable, assuming that the limiting (initial and final) orbits do not osculate and that the maneuver speed is minimized for optimum flight. The problem is treated without the restriction of coplanarity. After the boundaries for the vector of coupled variables have been established, nondegenerate three-impulse flights and a few classes of two-impulse flights are tested for optimality. Some are found which satisfy the necessary conditions, but not the sufficient ones. The three-impulse flights are tested for optimality. Some are found which satisfy the necessary conditions, but not the sufficient ones. The three-impulse flights do not satisfy them when the limiting orbits are sufficiently close, when the maximum number of impulses for optimum flight must be smaller than three over the entire $e = 0.1$ range of orbit eccentricity. The two-impulse flights do not necessarily safisfy them, requiring the same characteristic maneuver speed as some one-impulse flight. The author thanks V.A. Antonov, doctor of physico-mathematical sciences, for helpful discussion and for confirming by original analysis the results of computer-aided numerical calculations with regard to three-impulse flights. Figures 3; references 7: 5 Russian, 2 Western.

DURABILITY TO FATIGUE OF FLEXIBLE WING IN COUPLED MOTION PROBLEM

[Article by B.A. Yershov]

[Abstract] While increasing the flexibility of wings improves the performance of an aircraft, there is the problem of fatigue in a turbulent atmosphere representing a randomly fluctuating load. There has been established a relation between the service life of a flexible wing and statistics of wing deformation, namely $T\sigma_w^{1/2m} = AR$ (T - time till wing fracture under randomly fluctuating load, σ_w- dispersion of wing strains, m,A- parameters of Weller curve, R- fatigue resistance coefficient). The fatigue resistance coefficient represents the integral spectral density of wing strains over the entire time frequency range from 0 to ∞, in a form which depends on theparticular hypothesis of wing life (spectral summation, intersections, amplitudes). For a wing moving at some velocity through a turbulent atmosphere, this time spectral density depends not only on the wing velocity but also on the space spectral density of wing strains and on the parameters of the turbulence model. With these data given, it is possible to calculate and thus predict the life of a flexible wing moving at supersonic velocity through an atmosphere with vertical wind fluctuations. References 5: 4 Russian, 1 Western (in Russian translation).

INVESTIGATION OF SPATIAL HYPERSONIC VISCOUS SHOCK LAYER ON BLUNTED BODIES IN FLOW AT ANGLES OF ATTACK AND SLIP

[Article by E.A. Gershbeyn (deceased), V.G. Krupa, and V.S. Shchelin]

[Abstract] A hypersonic stream of nonequilibrium dissociating air over the surface of smooth blunted bodies with catalytic surfaces is investigated. An approximate numerical method is proposed for solving the equations describing the hypersonic spatial viscous shock layer. The flow about elliptical paraboloids at various angles of attack and slip is analyzed. Eleonor Arkadyevich Gershbeyn (1937-1985) wrote a treatise on hypersonic aerodynamics and a number of related articles on boundary and shock layers, gas dynamics an heat exchange in multicomponent gases. Figures 3; references 14: 6 Russian, 8 Western.

SURFACE TRANSPORTATION

ETHANE-PROPANE FUEL--A REPLACEMENT FOR HIGH OCTANE GASOLINE

Moscow GAZOVAYA PROMYSHLENNOST in Russian No 3, Mar 86 p 18

[Article by A.I. Gritsenko, A.V. Frolov, Yu.V. Surkov, V.I. Mayorov and
V.A. Astakhov, VNIIgaz]

[Text] In order to organize the production of low cost
replacements for high-octane gasolines it is proposed to use,
as a motor fuel, liquid ethane with small additives of
propane, butane or mixtures -- ethane-propane fuel (EPF).

Unstable condensates and petroluem, natural and petroleum gas and gas from
pyrolisis and cracked hydrocarbons can serve as raw material for EPF production.
The ethane contained in these raw materials are usually used irrationally.

Fairly simple calculations show that it is now possible to expand the
production of this type of fuel at existing gas industry enterprises to at
least 500,000 tons annually.

To assure low cost for the new product, VNIIgaz has developed a low energy
technology for EPF production, using the side selection of the fraction
needed.* The suggested method is based upon an analysis of reverse processes
in fractionation.

This scheme's simplicity permits EPF production using equipment at existing
facilities for condensate stabilization and gas processing plants through
simple changes in process conditions.

EPF production in a typical condenstate stabilization unit consists of the
following: In the first absorbtion-stripper column the deethanator is shifted
to demethanization, while the sought-for fraction is drawn off in a gas phase
from one of the plates in the stripper section, where the methane is
practically exhausted.

The implementation of this engineering solution requires an additional
compressor to receive the ethane fraction at a pressure of 1.6-2 MPa and
compress it to 5 MPa and an air cooler for condensing the product. Also, for

safe storage and reliable operation it is necessary to work out a system for "hot" servicing, in which tanks are filled at a higher temperature than storage and operating temperatures.

The recommended range for operating temperatures (20° C and lower) also corresponds to the region in which EPF density is sufficiently high and the dependence of density upon temperature becomes gently sloping.

EPF fuel is a liquid mixture of ethane and propane or butane with the following indicators.

Table

Ethane content at 50 °C (percent)	Not more than 73
Ethane content at 30 °C (percent)	Not more than 96
Butane content (percent)	Not rated
Pressure of saturated vapors at 50 °C, MPa	Not more than 5
Content of C_{5+}, (percent)	Not more than 2
Density at 20 °C, kg/m^3	More than 360
Density at 0 °C, kg/m^3	More than 417
Octane number by Motor Method	Not less than 93
Lower mass heat of combustion kJ/kg	46,200

As is seen, EPF butane content is not normed, as its presence in the fuel does not harm it.

However, EPF is a liquid with increased pressure of saturated vapors, exceeding the saturated vapor pressure of liquified gases. Therefore, it can only be used in vehicles equipped with tanks for compressed natural gas. The high pressure of saturated vapors in EPF permits it to be evaporated without preheating. Its operating conditions are close to those of compressed natural gas and thus cause no difficulties. Eight standard 100 liter tanks full of such fuel run an automobile more than 1,200 km.

The quickest introduction of this engineering solution requires operational solutions to questions of storage, transportation and filling tanks with such fuel.

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* "Improvements in the Technology for Stabilizing Gas Condensate", B. G. Bergo, A. V. Frolov, L. L. Fisman and others, Obzor Ser: "Podgotovka e pererabotka gaza i gazovogo kondensata" [Preparation and Refining of Gas and Gas Condensate] VNIIEgazprom, 1984

COMMERCIAL GASOLINES BASED UPON URENGOY GAS CONDENSATE

[Article by M. A. Tanatarov (UNI), R.S. Suleymanov (Urengoygazodobycha imeni S.A. Orudzhev) and L.N. Frolova, A.T. Gilmutdinov (Sterlitmak Affiliate UNI)]

[Text] A-76 and AI-93 grade commercial gasolines are obtained by blending the gasoline fraction of gas condensate from the Urengoy Field with high octane additives. Engine testing of the fuels showed their high efficiency. The production ans use of motor vehicle gasoline based upon gas condensate will meet the gas extraction region's needs for motor fuels.

Urengoy gas condensate is a gasoline-gas oil fraction. The sought-for product for the UPD-501 facility refining gas condensate is diesel fuel of a wide fractional composition. With regard to its basic physical-chemical composition, the gas condensate's gasoline fraction obtained at the facility is similar to commercial gasoline, but has lower antiknock properties.

In inaccessible regions it is not profitable to build and operate facilities for the secondary refining of gas condensate gasoline (selective hydrocracking, deparaffinization, thermal reforming). It is more advisable to to obtain motor vehicle gasoline by compounding the gasoline fractions of gas condensate with high octane additives.

In order to obtain mixed fuels it is only necessary that the refining scheme be equipped with capacity for storing high octane additives and commercial gasoline.

Fuel combinations of A-76 and AI-93 motor vehicle gasolines based upon Urengoy gas condensate gasoline were produced and tested under laboratory conditions. Aromatic hydrocarbons, methanol and isopropyl alcohol were used as high octane components. The fuel mixtures were tested on a MZMA-408 four cycle carburator equipped engine.

The table gives the composition and physical-chemical properties of fuel compositions based upon gas condensate gasoline from the Urengoy Field. They

correspond completely to commercial gasoline. The lighter fractional composition of the fuels assures the reliable starting, combustion and operation of motor vehicle engines in northern conditions.

Table

Composition and Physical-Chemical Properties of Fuel Blends

	A-76				AI-93	
Components	Fuel Blends					
	1	2	3	4	5	6
Composition:						
Gas condensate gasoline with OChMM 69.9	90.0	70.0	66.0	84.0	61.0	60.0
Methanol	5.0	5.0				15.0
Isopropyl alcohol	5.0					25.0
AI-93 gasoline		25.0	34.0			
Aromatic hydrocarbons				16.0	39.0	
Octane number						
Motor Method	75.8	75.8	76.2	76.0	84.8	84.0
Research Method	--	--	--	--	--	--
Fractional composition, °C						
start	36.0	32.0	35.0	40.0	40.0	33.0
10 percent	64.0	64.0	68.0	65.0	65.0	62.0
50 percent	94.0	96.0	102.0	96.0	86.0	92.0
90 percent	125.0	162.0	165.0	142.0	140.0	132.0
end	152.0	180.0	186.0	149.0	152.0	149.0
Residues + losses (percent)	2.0	1.5	1.5	1.5	1.8	1.8
Actual tar content, mg/100 ml	1.5	2.2	2.4	3.0	4.2	2.8
Density at 20 °C g/cm^3	0.7180	0.7140	0.7110	0.7230	0.7280	0.7280

Note: All fuel blends have destabilization temperatures below -35 °C and contain no solid additives

When the engine used fuel compositions with oxygen containing compounds, effective power increased by 2-8 percent. There was stable engine operation in

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the range of lean mixtures (alpha = 1.2 - 1.4), and fuel economy declined by 5-10 percent. However, stable operation in the lean mixture range gives additional advantages in improved fuel economies.

ADVANTAGES OF NATURAL GAS AS MOTOR FUEL SURVEYED

[Article by M. Dzhalayev and D. Volfram: "Natural Gas Instead of Gasoline"]

[Text] At the 40th Session of CEMA, chairmen of the central planning organs of Bulgaria, Hungary, the GDR, Cuba, Poland, Romania, the USSR and Czechoslovakia signed a General Agreement on multilateral collaboration in the use of natural gas as a motor vehicle fuel. M. Dzhalayev and D. Volfram, advistors to the CEMA Secretariat, explain its importance in improving the fuel and energy balances of the fraternal countries.

In the immediate future natural gas will be widely used as a fuel for internal combustion engines. Keeping in mind that 1 cubic meter of it replaces 1 liter of gasoline, the energy from 1 billion cubic meters of this valuable raw material is equivalent to 0.7-1.0 million tons of petroleum based motor fuel. The use of natural gas is beneficial in that it increases vehicle service life between repairs by 1.5 fold, reduces oil use by 15-30 percent, increases engine life by 30-40 percent, and halves the share of fuel costs in transportation costs.

Natural gas began to be used as a vehicle fuel in the Soviet Union back in the 1950's, when about 20,000 trucks were converted to compressed gas and 20 compressor stations were built to service them. However, due to the rapid development of the oil industry, the use of natural gas in vehicles was not further expanded.

Now, because of the need to improve the fuel and energy balance, this problem has again become acute. The massive conversion to gas fuel requires solutions to a number of difficult technical problems. For example, up until now it was thought that in order to use natural gas at a pressure of 200 atmosphere, vehicles needed steel tanks weighing up to 100 kg. However, this reduces freight capacity and length of run. Research conducted in the USSR showed a solution. It turns out that it is better to build tanks from composite materials rather than steel. For example, by using metal-plastics, tank weight can be reduced to not more than 40 kg. Weight can be further reduced by using highly gas-tight plastics.

There is another solution, instead of compressing natural gas, liquifying it, so it only occupies 1/640 of its previous volume.

Liquified natural gas (LNG) is now quite widely used in a number of developed capitalist countries. Last year its share in the total consumption of natural gas in the countries of Western Europe was about 23 percent, in the U.S. -- 22 percent and in Japan -- 25 percent.

Experience shows that the conversion of motor vehicle, ship and helicopter internal combustion engines to LNG does not present any serious technological difficulties, is economically advisable, as it increases engine service life between repairs by 1.5-2 fold and cuts oil use in half compared to engines using petroleum based fuel. Also, according to data from a number of firms, the content of CO and CO_2 in exhaust gases is reduced 5-20 fold, and that of other toxic substances is reduced several fold compared to when gasoline is used.

Due to the considerable increase in the value of petroleum fuels and in order to reduce their consumption, scientific-technical and practical work on the use of LNG has already begun in the USSR. Studies show that outlays for its replacement of gasoline between now and 1990 will be about equal to the costs of making gasoline from fuel oil and will be 3-4 fold less than for making synthetic gasoline from coal.

However, the widespread use of LNG as a vehicle fuel requires the construction of cryogenic installations, essentially factories for its production. It also requires a large number of reservoirs for isothermic storage, tanker truck and railroad tank cars, service stations, etc. It is also necessary to master the series production of fuel tanks from aluminum alloys. These tanks should have good insulation properties and a system for supplying fuel to vehicle engines. Practical experience and economic expediency shows that all these problems can only be successfully solved through the expansion of bilateral and multilateral ties between CEMA countries. There are prerequisites for this. The general agreement approved at the 40th Session is directed towards setting up such collaboration.

From now on, interested countries will combine their efforts to create equipment for the production of compressed and liquified natural gas and means for its transportation and use by transportation equipment.

There is also much to do in improving transportation equipment and fitting out engines for natural gas. In the future new designs permitting the more effective use of this fuel must be created.

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PROBLEMS WITH CONVERTING MOTOR VEHICLES TO COMPRESSED [NATURAL] GAS FUEL [CNG]

Alma-Ata NARODNOYE KHOZYAYSTVO KAZAKHSTANA in Russian No 1, Jan 86 pp 17-19

[Article by the first deputy of the Kazakh SSR Ministry of Motor Vehicle Transport G. Yesmambetov "What is in the Way of Converting Motor Vehicles to Compressed Gas Fuel"; first two paragraphs are NARODNOYE KHOZYAYSTVO KAZAKHSTANA introduction]

[Text] Our reader from Chimkent, G. Gevorkyan is worried about the status of implementing a promising and economically profitable innovation - using inexpensive compressed gas instead of expensive and scarce gasoline as a fuel for motor vehicle transport. He set forth his thoughts, concerns and proposals in an article that was published in our magazine (No 9, 1985).

The Kazakh SSR Ministry of Motor Vehicle Transport has responded to the article. First deputy Minister G. Yesmambetov is taking up the conversation on this topical issue.

The Kazakh SSR Ministry of Motor Vehicle Transport considers the publication of this material now, when the draft of the "Main Directions of Economical and Social Development of the Country" is being discussed, quite timely. Among other things, the draft requires to "Significantly expand the production of motor vehicles using compressed and liquified [natural] gas as a fuel.

As the Ministry understands the importance of saving and rational utilization of fuel and energy resources, especially liquid oil-based fuel, we converted some ZIL and GAS cars and trucks in Alma-Ata to compressed gas.

Now, seven years later, over 1,800 trucks and 300 taxi-cabs GAZ-24-07 in our republic capital operate on compressed gas. We understand that this is only the beginning, and we are expanding the scope of the work.

Beginning in 1984, the Ministry started implementation of a sweeping program for using compressed gas as a fuel for motor vehicles. Now 3,220 trucks in Alma-Ata, Dzhambul, Chimkent, Uralsk and Rudnyy use it. Only one-third of the total amount of bottled gas motor vehicles that run on compressed gas were received from the Ministry of Automotive Industry plants; the remaining 65% were converted in our motor vehicle facilities.

This had been preceded by the creation of the educational and manufacturing basis for training drivers, repairmen and engineering and tecnical personnel. Steps were taken to assure dependable operation and maintenance and to create

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proper conditions for receiving bottled gas motor vehicles. 3,500 specialists had been trained in Ministry's training centers. Specialized departments for converting motor vehicles and for repair and maintenance of CNG equipment were opened in 20 automotive facilities. 1,100 sets of tools with copper coated surfaces for installation of CNG equipment will be manufactured; 300 of them have already been delivered.

NPO [Scientific Production Organization] "Kazavtotranstekhnika" has developed a stand for adjustment and testing of CNG equipment. Transport facilities have been issued standard and procedural documentation on operation, maintenance and testing of motor vehicles fuel systems. Scientific research is performed in order to assess design features and dependability of bottled gas motor vehicles.

In 1986 we plan to expand the use of compressed gas fuel in passenger transportation. It will become possible after having received new LAZ-695 NG buses, manufactured by the Lvov bus plant, that can operate on compressed natural gas.

Due to the measures that had been taken, the volume of transportation via motor vehicles running on compressed and liquified gas has considerably increased. Before 1985 ended, the 160 million ton-km barrier was exceeded. As a result, over 10,000 t of gasoline had been saved. Besides, this made it possible to clean air basins in many cities from hazardous exhausts of motor vehicles.

It is anticipated that during the current 5-year plan period the general use motor vehicle fleet in the northern and western oblasts of the Republic will be increased by a significant number of bottled gas motor vehicles. Taking this increase into account, the Ministry has started solving practical problems of constructing new and reconstructing the existing manufacturing base, personnel training and organization of freight traffic, as these activities apply to specific features of operation and maintenance of motor vehicles that run on compressed gas fuel. Measures are taken to create in 1986-1987 facilities in Alma-Ata, Dzhambul, Chimkent, Uralsk and Rudnyy for periodic inspection of gas bottles and testing of fuel systems of motor vehicles for leak-proofness...

NPO "Kazavtotranstekhnika" developed a statute for such facilities, prepared technical and economical justification for construction thereof (the total construction cost is 5 million R) and is preparing technical documentation; necessary equipment has been been ordered from appropriate republic agencies, the problem of allotment of land parcels has been solved.

At the same time, to further expand the use of compressed [CNG] natural gas as a motor vehicle fuel, some urgent problems should be immediately solved.

This refers first of all to the development of the network of automated CNG filling stations (AGFS). It is no secret that today a significant portion of bottled gas motor vehicles are located at facilities that are, on the average, 30 to 40 km away from CNG filling stations.

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More than a half of all bottled gas motor vehicles are involved in intraoblast and intercity transport. However, lack of CNG filling stations at highways and in rayons makes it necessary to use in motor vehicles two types of fuel (compressed gas and gasoline).

During the harvesting campaign bottled gas motor vehicles also often run on gasoline, which is, of course, abnormal. (Last year Minavtotrans transfered 1,500 of such vehicles from the southern to the virgin land oblasts). In order to preclude running of bottled gas motor vehicles on gasoline in intraoblast transport, the Ministry (in accordance with the pipeline route and the prospects for its development) came to the republic Gosplan with a proposal to build gas filling stations in Aktyubinsk, Guryev, Kustanay, Dzhetygar, Shevchenko, Novyy Uzen and in the settlement of Dzhetybay; in the Alma-Ata Oblast in Kapchagay, Chilik and Uzunagach; in the Dzhambul Oblast in Karatau, Merk and Chu; in the Chimkent Oblast in Turkestan, Saryagach, Lenger, Temirlanovka, Vannovka and Arys.

A decision has been also made to solve the problem of manufacturing of mobile compressed gas bowsers by manufacturing facilities of the industry, which will make it possible to refuel motor vehicles en route and at points of destination, and the problem of manufacturing trailers with bottled gas equipment that can operate with trucks, which will make it possible to increase the route length. Unfortunately, as no industrial prototypes are available, the Ministry is compelled to use only part of its complement of bottled-gas equipment.

The conversion of motor vehicle transport to compressed gas is held back considerably by the lack of gas drying and rectifying equipment at gas filling stations. As a result, the quality of compressed gas does not meet specifications, as the content of mechanical impurities and moisture is more than 20 (!) times higher than standard.

The Ministry has been repeatedly asking the Mingazprom to take steps to improve the quality of compressed gas; however, for all practical purposes the problem has not been solved yet.

In the meantime, the low quality of gas leads to increased engine wear, premature failure of low and high pressure regulators and solenoid valves, and higher than normal moisture content impedes starting of engines, especially during the winter time. Due to these reasons, over 300 sets of CNG equipment have already failed. It is quite a tangible loss, as no funds for CNG equipment spare parts were allocated in 1984 and 1985.

Inconsistent operation of AGFS, lack of compressed gas and malfunctioning of compressors often lead to stoppage of motor vehicle transport operations. Thus, in June and July of 1985 Alma-Ata gas filling station No. 1 had been out of production for nine days, and as a result autotransport facilities had lost 4,000 vehicle-days. Over 150 extra tons of gasoline were consumed. A similar situation exists at Chimkent CNG filling stations.

The quality of gas filling hoses is very low. They can only withstand 160 atmospheres of pressure instead of 200. Motor vehicles are not being filled

up to capacity even in summer (let alone the winter months when gas pressure in the main pipeline drops to 3-5 atmospheres), and this shortens the operating range of vehicles by 20 to 25%.

Safety of bottled gas motor vehicles is an acute problem. Periodic testing of fuel systems and inspection of compressed gas bottles must be performed at specialized stations. However, construction of these stations is being held back due to the lack of design and estimating documentation that is being prepared by "Giproavtotrans", as well as by the lack of equipment, especially high pressure compressors.

There are not enough incentives to encourage operation of bottled gas motor vehicles. The engine power drops 18 to 20%, dynamic traction and performance parameters deteriorate, and this leads to lower productivity which affects drivers' earnings. Probably for those drivers operating bottled gas motor vehicles 15 to 20% higher hourly rates should be established. This raise will be entirely offset by the lower price of compressed gas compared to liquid fuel.

In September of 1985 the Ministry board reviewed measures directed at improving the utilization of bottled gas motor vehicles at its production facilities. It was decided to continue the reduction of gasoline consumption by replacing gasoline with gas fuel and to make managers more responsible financially for using gasoline in bottled gas motor vehicles.

The growth of the fleet of motor vehicles running on compressed and condensed natural gas will have considerable economical effect and will also decrease the degree of air basin pollution. But this is up not just to automobilists alone. In this we need the assistance and concrete help of our partners.

EFFECT OF DRAG FROM PAVED ROAD ON MOTOR VEHICLE PERFORMANCE

[Article by R.V. Virakov, doctor of technical sciences, A.N. Mamayev, candidate
of technical sciences, V.L. Medoks, candidate of technical sciences,
T.M. Petrova, candidate of technical sciences, A.A. Romanchenko, engineer,
and M.Yu. Chebotareva, engineer]

[Abstract] Especially four motor vehicle operating characteristics determine
the traction dynamics, and thus the drag force, of a motor vehicle: location
of the center of mass, air pressure in the tires, transmission scheme, and
mode of interaxle drive. An analysis of the relations involved here takes
into account the effect which the tangential forces at the points of wheel-
to-road contact have on the load distribution between axles, this load
distribution determining the behavior of the tires under kinematic and
dynamic conditions and thus in turn determining those tangential forces.
The three-axle 6x6 motor vehicle is assumed to move in a straight line at
a constant speed on an even hard road. The two wheels on each axle are
assumed to be identical, the differential gears between them remaining idle.
Losses in the transmission are disregarded, but friction losses at the wheel-
to-road contact and hysteresis losses in the tires are included. The
tangential forces at the wheel-to-road contact points are assumed to never
reach the seizing level. Three equations of balance for forces and moments,
one load equation, and one equation of motion are formulated with the aid
of empirical relations, for the drag coefficient (ratio of drag force to
weight) according to V.A. Petrushov and for the dynamic radii of wheels
(assumed to be equal to the static radii) according to A.N. Yevgrafov. The
last equation, namely the torque equation, needed for solution of the
problem depends on the mode of interaxle drive. Two cases are considered,
namely an unlocked interaxle differential and a locked one. Calculations
based on these six equations for vehicles weighing 14,260-15,260 kg on
0I-25/400-20 tires with the air pressure varied over the 0.24-0.32 MPa
range, and with the distance from the center of mass to the front axle
varied over the 2200-3700 mm range in 300 mm or smaller steps, were made for
speeds of 50 km/h and 85 km/h. The results indicate that the drag coefficient
is minimum at some distance between the center of mass and the front axle. They
also indicate that locking an interaxle differential may result in negative
torques and thus braking action on some axles. Figures 4; references: 4
Russian.

CHERNOBYL NUCLEAR ACCIDENT DISCUSSED IN PRESS CONFERENCE
Chernobyl Situation Update
Radiation Dosage Levels Discussed

Moscow NTR: PROBLEMY I RESHENIYA in Russian No 10, May-Jun 86 p 3

[Statement by M.S. Gorbachev, excerpts from press conference at USSR Ministry
of Foreign Affairs and interview with V. Knizhnikov, member of the Soviet
National Commission on Radiation Safety]

[Text] Chernobyl: Days of Testing

"The indisputable lesson of Chernobyl for us is that with the further expan-
sion of the scientific and technical revolution, questions of equipment
reliability, its safety as well as questions of discipline, order and good
organization become of first rate importance." From the address of M.S.
Gorbachev on Soviet television, 14 May 86.

The Soviet people, confronting an awesome force - nuclear power that has
gotten out of control - have mobilized all of their highest public-spirited
and creative potential. Builders and helicopter pilots, physicians and
drivers, academicians and ministers have been self-sacrificing in working
around the clock to eliminate the consequences of the accident. The worst
is already behind us. But considerable efforts are still needed in order to
eliminate all of the consequences.

Member of the Soviet National Commission on Radiation Safety, Doctor of
Medical Sciences V. Knizhnikov comments on the medical and biological aspects
of the work that has been done and the upcoming efforts.

In the photograph [not reproduced]: the members of the governmental commis-
sion. From left to right: I.S. Silayev - Deputy Chairman of the USSR
Council of Ministers and Chairman of the State Commission; Yu.A. Izrael -
Chairman of the USSR State Committee on Hydrometeorology and Environmental
Monitoring; Ye.P. Velikhov - Vice-President of the USSR Academy of Sciences.

Moscow: Press Center of the USSR Ministry of Foreign Affairs.

The directors of the International Atomic Energy Agency (IAEA) held a press
conference in Moscow to sum up the visit to the Chernobyl AES [nuclear electric
power plant].

"We were able to gain a rather complete, although preliminary understanding of the accident and its consequences in extremely frank discussions with Soviet specialists, responsible individuals and from visual inspections at the site of the accident," stated the general director of the IAEA, H. Bliks (Sweden). "As a result of the steps that have been taken, the situation at the damaged unit is stabilized and the radiation status has been rendered normal in the region of the Chernobyl AES."

This and other statements made by H. Bliks, his deputy L. Konstantinov (USSR) and the director of the nuclear safety department of the agency, M. Rosen (U.S.), clearly demonstrated the complete irresponsibility of those who are exploiting this accident in order to launch a campaign of ill-will towards our country and simply to slander. But you judge for yourself.

Here are two typical questions from Western correspondents and the answers of the directors of the IAEA (cited from stenographic dictation).

The newspaper "The Philadelphia Inquirer" (U.S.): Are you convinced that persons living within a 30 kilometer radius are not at all threatened? Are the radiation levels there completely safe?

M. Rosen: The levels that are now being measured along the perimeter of this region are 0.15 milliroentgens per hour, and this should not lead to any obvious health consequences for the populace in this area.

Question of a correspondent from Kuwait: Students and graduate students from many states are in Kiev and Minsk, including students from the Arab nations. Does this accident represent any danger to their life and health?

H. Bliks: I can answer this for you as follows. We were in Kiev yesterday and life there was quite ordinary. There were many people on the streets . . . . what we saw shows that life is going on completely normally. We asked questions as to whether the schools were closed. We were answered quite definitely "No" . . .

In summing up such questions, H. Bliks emphasized the fact that the mass media "are obligated in this particular and in other cases not to exaggerate the events and not to spread various kinds of rumors that can only cause anxiety among the people."

For Your Information

An absorbed dose is the ionizing radiation energy absorbed by the irradiated matter figured per unit of its mass. It is measured in rads. One rad corresponds to an absorbed energy of 0.01 J/kg.

The biological effects caused by any ionizing radiations are conventionally compared with the effects from X-rays and gamma radiation. The equivalent dose is introduced for this purpose; it is defined as the product of the absorbed dose times a factor that depends on the kind of radiation. This factor is unity for X-radiation. The equivalent dose is measured in rems

(roentgen equivalent man). One rem of X-ray radiation corresponds to one rad of an absorbed radiation dose.

The exposure dose, measured with respect to the ionization of air, characterizes the radiation level. It determines the number of ions formed per unit volume of air and is measured in roentgens. One roentgen corresponds to the generation of 2.08×10^9 pairs of ions per cm^3 of air. It can be assumed in estimations that an equivalent dose of one rem corresponds to an exposure dose of one roentgen.

The maximum acceptable doses for man are regulated by the state Radiation Safety Norms, NRB-76, adopted in 1976. The maximum permissible dose per year (PDD) for personnel working with radioactive materials has been set at 5 rem/year. The PDD is the maximum value of an individual dose over a year, which during a 50 year exposure will not cause unfavorable changes in man. The dose limit per year (PD) for the populace has been set at a 10 times lower level: 500 millirem/year.

Thus, with the radiation level on the order of 0.3 milliroentgens per hour, which is now being observed at the boundary of the 30 kilometer radius around the Chernobyl AES, and with the exponential decay of its intensity with time and a half-life of eight days (the half-life of the iodine 131 radioactive isotope), the equivalent annual dose will be a small fraction of the PD dose limit.

The Danger is Receding

Conversation With V. Knizhnikov, member of the Soviet National Commission on Radiation Safety

[V. Knizhnikov] A disaster has occurred in our country. On April 26th, 1986, at 1:23 AM, an accident occurred in the fourth power unit of the Chernobyl AES during its scheduled shutdown.

The reactor core was partially destroyed in this case and the nuclear fission fragments escaped from the plant. Two persons died from thermal burns and mechanical trauma in the accident itself. Injured AES workers and firemen were hospitalized, some in critical condition. Radiation sickness subsequently developed among some of the persons who were close to the reactor. Several of them were given bone marrow transplants on 8 May. The transplants were provided by their closest relatives in order to prevent possible rejection. Seven persons who sustained severe radiation exposure died by 14 May.

The radioactivity that escaped into the atmosphere produced a definite increase in the natural background over the territory of the Ukraine, Belorussia and individual regions of the RSFSR, Poland, Rumania and the Scandinavian countries.

This is the extent of our disaster.

[NTR: PROBLEMY I RESHENIYA] How great was the danger to residents of the evacuated areas?

[V. Knizhnikov] As soon as it became clear that a serious radiation emergency was involved, measures were immediately taken to evacuate the population. You yourself understand that some time was needed to organize this, but I would like to say right at the outset that the radiation doses in the populated areas were not such that the people could have been significantly irradiated prior to the time of evacuation. Observations are being made of all of those who were in the now evacuated settlements; the people were immediately examined by means of radiometric instruments. Of the tens of thousands of persons, only among a portion has a considerable "contamination" of the clothing been discovered, and they were included among those persons being kept under continual clinical observation.

[NTR: PROBLEMY I RESHENIYA] And what was the situation outside of the 30 kilometer radius around the Chernobyl AES?

[V. Knizhnikov] The composition of the radioactive emissions from the reactor was such that one of the iodine isotopes, iodine-131, is "making radiation weather". Its half-life is eight days.

As you know, the prevailing winds at the time of the accident were northern and north-western. For this reason, an increase in radioactivity was noted in the direction of Gomel, in Poland, and two days later, an increase in the radioactive background was registered in Sweden.

[NTR: PROBLEMY I RESHENIYA] How dangerous was all of this for the people?

[V. Knizhnikov] The radiation levels in Sweden, although they exceeded the standard background values by several times, nonetheless represent no threat at all to the health of the people. Moreover, these levels only held up there for a few days and the situation now in Sweden is practically completely normalized. I will say in anticipating your question that no changes at all have been observed in the radiation background in Moscow over the time since the accident occurred at the Chernobyl AES.

As you know, doses on the order of 0.3 milliroentgens per hour are now being recorded in the region of Kiev. Such concentrations are practically typical of territories adjacent to the 30 kilometer radius around nuclear power plants.

[NTR: PROBLEMY I RESHENIYA] What is 0.3 milliroentgens per hour? Is this a little or a lot and is it dangerous to health or not?

[V. Knizhnikov] Well then, let us do some calculating and compare. This means that a person, depending on how he behaves, "will receive" about 150 milliroentgens per month, or as we still say, 150 millirems (a rem is the roentgen equivalent man). It was no accident that I used the concept of "behavior". This means that a person spends approximately 10 hours on the street and about 14 in a room where the dose is naturally several times less than in the open.

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And let us now go a step further. The natural radiation dose, from which we usually "start", is about 100 milliroentgens per year. And this is the dose we receive over our entire life, that is, 70 years in a row. But this does not exhaust the amount today. The natural radioactive background amounts to only approximately one-third of the so-called general background population dose. Yet another third is the dose received by persons during medical diagnostic procedures. This is approximately 140 milliroentgens per year in our country, 160 milliroentgens in Poland and 180 milliroentgens in Japan. The remainder of the dose is produced, and this I think will be news to you, by man just being in present-day rooms. The fact is that such radioactive elements as uranium, thorium and especially radium-226 are present in brick, and in particular, in concrete. And if these radiations are equated in terms of risk to the dose irradiating the entire body, then this comprises yet about another 150 milliroentgens.

And I underscore the fact that all of this is the usual environment for us in which we live and to which modern man is adapted. Notice that I am omitting from our consideration such additional radiation sources as aircraft flights, watching television, the consequences of global radioactive fallout from nuclear explosions in the atmosphere conducted up until 1963 as well as the "contribution" of radioactive materials contained in the emissions from coal-fired electric power plants. So if you do not take these factors into account, then each rural resident today receives a dose of about 350 milliroentgens annually, while a city resident receives a dose close to 500 milliroentgens. But the figures cited here are average ones. They are considerably higher in individual regions of the globe. For example, in the state of Keral in India, in Brazil and in the central granite massif in France. There the background is five to six times above the average level, but no deviations have been recorded in the health of tens and tens of thousands of people.

The dose that Kiev residents may receive per month following the accident is 150 milliroentgens. I am speaking specifically about one month, since the issue here is iodine-131 and other short-lived radioactive isotopes, which now determine the external radiation dose. This means that the received dose power will fall off rapidly. And such radiation decay in the absence of additional contamination eliminates all questions of any danger to health.

(NTR: PROBLEMY I RESHENIYA] What levels of radiation then represent a danger to our health?

[V. Knizhnikov] According to estimates of the International Commission on Radiological Protection, the appearance of specific radiation effects extended over time can be anticipated only at doses exceeding 50 rem per year. Radiation sickness occurs with a one-time exposure to doses of more than 75 to 100 rem. As far as radiation burns are concerned, they occur only at doses of hundreds and thousands of rem.

We have set strict standards for the radiation dose not only because of fear of radiation sickness, but also because of the fact that radiation did not have those consequences that are termed distant. These are primarily

malignant diseases and genetic defects. These consequences have been undis-
putably demonstrated for irradiation of 100 rem and more. But existing
theoretical concepts force us to believe that even low radiation doses can
be a carcinogenic factor. The extraordinarily cautious position of
researchers, who clearly overestimate the possible risk, is as follows: any
additional radiation leads to an increase in the risk of cancer.

From this viewpoint, which incidentally, I share, there is unquestionably a
risk from the additional radiation due to the accident, but it is insigni-
ficant and incomparably lower than the risk of being killed in a motor
vehicle accident or dying from the same lung cancer caused by smoking
cigarettes. In a word, I would like to say just one thing: the risk to the
residents of Kiev, for example, of dying of cancer because of the present
increase in the background radiation is considerably less than for persons
living close to a modern, high power coal-fired electric power plant. It is
at the level of the risk existing with an ordinary X-ray examination.

[NTR: PROBLEMY I RESHENIYA] What can be said in this regard concerning the
problem of food product safety?

[V. Knizhnikov] Well, I will not cover up the facts. Milk and fresh greens -
onions, parsley, dill and fennel may be contaminated. But they are being
subjected to constant radiometric monitoring. So you can be confident that
not one batch of vegetables that does not meet public health standards will
go on the market. As far as the crop of vegetables, fruits and grain, there
is simply no basis for anxiety. The harvest will come in after two to three
months and the iodine-131 activity will decrease by 1,000 times during this
period. In other words, the new harvest will be absolutely clean. This
reflects the actual state of affairs and the viewpoint of the authoritative
radiological specialists.

Milk taken from cows eating fresh grass may be dangerous. Individual batches
of it have already had to be rejected. But incidentally, it is not being
sold and is going to reprocessing in order to make cheese or condensed milk.
Cheese, as you know, matures in two to three months, while condensed milk can
be stored for years. The iodine-131 activity will become insignificant in
80 to 90 days and these products will also be completely pure as regards
radiation.

[NTR: PROBLEMY I RESHENIYA] How was the notification of the accident at the
Chernobyl AES perceived by your foreign colleagues?

[V. Knizhnikov] With complete understanding and sincere participation. I
personally immediately received a telegram from Professor Pelerin, the director
of the World Health Organization Center in Paris. He offered informal
assistance both of medicine and instruments for monitoring the environmental
status. Similar proposals were made to the USSR Ministry of Health by
Professor Jame: the director of the Institute of Radiopathology, one of the
leading specialists on the International Commission for Radiological Safety.
American scientists have arrived in our country, as well as researchers from
other countries who have offered their knowledge and their assistance to us.

In a word, the response of the scientific community differs sharply from the positions of certain Western mass media. My foreign colleagues have perceived the accident at the Soviet nuclear power plant as an accident for all mankind, as a disaster which could have occurred in any country developing nuclear power engineering.

What has happened in our country once again forces us to think of how important it is to monitor the use of nuclear power. Even the minor radio-activity that escaped into the environment has become a source of considerable harm done to human life. But the scales of the nuclear disaster can become immeasurable if the most fearful thing breaks out, either accidentally or intentionally: nuclear conflict.

You will now sense and understand in an especially acute fashion how vitally important is the battle for the complete elimination of nuclear weapons, put forward in the statement by M.S. Gorbachev, on 15 Jan 86, and how necessary is the peaceful cooperation of scientists.

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STELLARATOR TECHNOLOGY TEN YEARS BEHIND TOKOMAKS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 15 Mar 86 p 4

[Interview with L. Kovrizhnykh, head of the USSR Academy of Sciences
General Physics Institute's Plasma Physics Department, by correspondent
M. Dmitruk; date and place not given]

[Excerpts] When the subject of controlled thermonuclear fusion comes up,
the famous tokamaks most often come to mind. Meanwhile, the high-
temperature plasma required for this reaction can be obtained in open
magnetic traps like the "Orga," by using lasers, and in other ways.
L. Kovrizhnykh, head of the USSR Academy of Sciences General Physics
Institute's Plasma Physics Department, doctor of physicomathematical
sciences, and winner of the Lenin Prize, tells our correspondent about one
research program, the stellarator.

[Question] Lev Mikhaylovich, to the nonspecialist it appears that the
tokamak and stellarator are similar, even in appearance, and their designs
also have a great deal in common. Why do certain scientists call the
research programs for these units "alternatives?"

[Answer] We know that heating plasma to 100 million degrees is not
enough for controlled thermonuclear fusion—we have to force it to burn
steadily. Achieving this with a tokamak isn't easy. There, heating
alternates with the pause required to remagnetize the coil which excites
current in the plasma. Therefore, constructing a commercial reactor with
pulsed operation involves tremendous technical difficulties—alternate
heating and cooling of plasma creates powerful thermal shocks which chamber
walls may not withstand.

There is no such danger with a stellarator. It can operate in steady-
state mode, and the current doesn't travel through a pinch. Constant
plasma temperature would make it possible to reduce structural fatigue
in materials for future commercial reactors and ensure reliable performance
of thermonuclear power plants.

[Question] Why then, despite several advantages, are stellarators nearly
10 years behind tokamaks in terms of basic indices?

[Answer] Both designs were created almost at the same time, in the early 1960's. Soviet scientists began working on tokamaks and achieved significant successes. American physicists, who were studying the feasibility of stellarators, were unsuccessful: the plasma dispersed in fractions of milliseconds. Deciding that this was due to basic deficiencies in these units, they stopped research.

Later, scientists in the USSR, Japan, and the FRG became interested in stellarators. Our country created several "Uragan" and "Liven" units. Research on them showed that there were no insurmountable problems and that the stellarators' defects could be eliminated if the configuration of windings in the chamber were changed. Moreover, the advantages of these units over tokamaks were experimentally proven. The strong helical field keeps plasma from being blown at the chamber walls, and it can burn for a rather long time in current-free mode. Finally, theoretical calculations performed by our Institute convince us that, in principle, one can create plasma with parameters required for commerical reactors in stellarators.

As you see, in most countries which are working on controlled thermonuclear fusion, an alternative program was created after the basic one, and it is no surprise that it is now noticeably behind. For example, in the "Liven-2," plasma exists for a total of 7 milliseconds; with a high-powered tokamak, a hundred times longer.

[Question] But controlled thermonuclear fusion requires that plasma burn for at least a second. Stellarators abroad have a rather long way to go to reach that point; tokamaks have come much closer.

[Answer] In fact, our country must create a prototype reactor in the near future--a tokamak which will show the fundamental feasibility of thermonuclear fusion. But for future commerical power plants, stellarators may turn out to be more promising. They can operate in steady-state mode--even now, plasms lasts in them longer than in tokamaks of the same size. And one might assume that this relationship will continue when large stellarators are built.

This is why it would now be worthwhile to construct stellarators comparable in scale to the last generation of tokamaks. Unfortunately, for several reasons it has been decided that our Institute will build a relatively small "Liven-2." Its characteristics are already inferior to those of foreign counterparts. Moreover, construction of this unit hasn't even begun yet.

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AUTOMATIC SYSTEM TO HOLD PLASMA CHORD IN EQUILIBRIUM POSITION IN TOKAMAK

[Article by I.M. Averin-Lavrov, Ye.I. Gusevskaya, and S.M. Naftulin]

[Abstract] Solid-state power amplifiers are used in the TO-1 and ORMAK
tokamaks to maintain the plasma in its equilibrium condition, requiring that
the control windings be inside the chamber. Automatic maintenance of plasma
position in a tokamak with control windings outside the chamber and a copper
cover requires a significant increase in the controlling magnetic field
intensity. A thyristor resonant inverter is used for this purpose, yielding
semisinusoidal current pulses. Loops or magnetic probes inside the chamber
are used to sense the movement of the plasma. The resonant inverter is
diagrammed and described. Introduction of the automatic system avoids
plasma instability, eliminating rapid movement of the plasma in the
vertical plane and interruption of the discharge current. Horizontal
movement can still occur. Figures 4; references 5: 4 Russian, 1 Western.

MODELING PROCESS OF TROUBLE SHOOTING OPERATIONAL SITUATION

[Article by A.F. Dyakov, candidate of technical sciences, USSR Ministry of
Power and Electrification, and S.D. Garbar, engineer, Krasnoyarsk Regional
Power System Administration (Krasnoyarskenergo)]

[Abstract] For the purpose of minimizing the time lost on shutdown follow-
ing a failure in a technologically intricate process such as operation of a
power plant, the performance of the human trouble shooter has been analyzed

on the basis of a preliminary study involving a crew of 18 such operators at the Nazarov GRES. The major difficulties in making the correct diagnosis were found to be conflicting information from several sources, inexperience, inability to recognize or determine the cause-effect relation, and tendency to oversimplify by disregarding nonlinearities as well as parameters of second-order significance. A hypothesis about the operator's behavior was then proposed in the form of a 5-step sequence of actions, namely operations on sets of parameters. A simulator has been constructed in accordance with this hypothesis for establishment of the cause-effect relation involving the state of the test object in the form of a system of statistical equations and a coefficients matrix, its elements characterizing the relations between parameters and also the operator's skill. The simulator solves this system of equations for any given process perturbation, after they have been linearized with the aid of Taylor series expansions. It was tested on trouble shooting of the BROU-1 rapid reduction and cooling system in one of the K-160-130 turbine sets and found to be adequate for training trouble shooters. Figures 1; tables 3; references: 1 Russian.

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UDC [621.311.25;621.039].007:658.3.012

HUMAN OPERATOR AS COMPONENT OF CONTROL SYSTEM IN NUCLEAR POWER PLANT AND NEED FOR OPTIMIZING INFORMATION BASE OF HIS/HER ACTIVITY

Moscow ELEKTRICHESKIYE STANTSII in Russian No 5, May 86 pp 18-22

[Article by V.I. Smutnev, A.V. Revin, and V.A. Yefryushkin, engineers, Novovoronezh AES and Novovoronezhatomenergonaladka [Office for Plant Setup]

[Abstract] Rational and comprehensive training of human operators in a nuclear power plant such as the Novovoronezh AES is absolutely necessary, considering that the human operator is the central and most responsible component in the plant control and regulation system. He/she receives and relays information, analyzes information for the purpose of decision making, programs and monitors operation of the system or any component of it, and acts according to whatever the situation requires. Decision and action of the operator depend essentially on the information made available within the time available to prevent a fault or shutdown. Fast and effective control of a nuclear power plant therefore requires availability of an optimum information base, reliable complete automation, and presence of highly skilled personnel. The information base must include parameters of transient processes and response characteristics of equipment. Optimization of this information base for most effective and reliable control of transients requires control panels adequately equipped with fast responding instruments, a high-speed computer with large memory capacity, an extensive advisory data bank of faults and countermeasures, and a network of full-scale training simulators. One ought to consider assigning one entire power generating unit in the nuclear plant

to educational activity only. Figures 1; references 3: 2 Russian,
1 Western.

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CAUSES OF UNDERPERFORMANCE OF MODERN DEAERATORS

[Article by L.N. Kurnyk, candidate of technical sciences, UralVII [All-Union
Institute of Heat Engineering, Ural Branch]

[Abstract] Thermal water deaerators with jet and bubbler columns have been
developed by the Ural branch of the All-Union Institute of Heat Engineering
jointly with NPO.TsKTI [the Scientific-Industrial Association of the Central
Boiler and Turbine Institute]. These deaerators, operating in thermal
electric and atomic electric power plants for about 10 years already, have
been found to often perform inadequately. The most serious deficiencies are
occasional passage of oxygen and free CO_2 into the feedwater, vibrations and
water hammer in both columns, splashing of water into the steam line, and
breakage of equipment. A design analysis of such a deaerator and of the
conventional type indicates that the steam velocity in the bubbling layer large-
ly determines the height of the foam layer in the bubbling column. Although
that height could possibly become excessive, experiments have established
that not the steam velocity but the pressure drop across the bubbler stage
is the main factor limiting the hydrodynamic stability and therefore must
not exceed the maximum permissible level. Premature flooding can be
caused by high drag of the water column in the bubbler stage, overflow
of the weir, or excessive resistance to flow in the dry components of the
steam bypass valve and of the bubbler stage. A redesign is therefore in
order, namely: maximally widening the critical cross-sections and decreas-
ing the hydraulic drag in the steam bypass valve, increasing both width and
height of the weir orifice, and improving the deaeration of the weir by
means of air suction devices. It is also necessary to prevent slumping of
water, the slumping rate D_{slump} (kg/s) being dependent on the water pressure
p_b (Pa) in the bubbler and the steam velocity w_{bh} in the bubbler holes in
accordance with the semiempirical relation $D_{slump} = 2.8 \cdot 10^{-4} p_b^{-0.62} w_{bh}^{-1.4}$.
Most expedient ways to achieve this have been found to be slanting the
bubbler toward the weir so as to minimize the load on the deaerator,
preventing entry of excessively underheated water into the bubbler, and
installation of special traps for slumping water. Figures 5; references:
7 Russian.

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PREDICTING CAVITATIONAL WEAR OF POWER EQUIPMENT

[Article by I.A. Shalobasov, candidate of technical sciences, All-Union Scientific Research Institute of Aviation Materials, A.Ya. Grinberg, candidate of technical sciences, All-Union Scientific Research Institute of Hydraulic Machinery Design, and V.A. Mikhaylov, E.D. Lunatsi and Yu.V. Kolomtsev, engineers, Kola AES]

[Abstract] Predicting cavitational wear of power equipment such as turbines, pumps, and accessories in atomic electric or thermal electric power plants is an essential part of design for reliability and economy, but no adequate theoretical method of prediction is available. An experimental method is proposed, therefore, which involves accelerated testing. Life and reliability are referred to a maximum allowable wear depth, maximum cavitation rate and breakdown incubation period are defined respectively as slope and time-axis intercept of the straight line tangent to the curve of cavitation kinetics (wear depth as function of time) through the inflection point. A reference material is selected for testing, preferably a fragile one, and the data are scaled to any given structural material, on the premise that the wear resistance is inversely proportional to the maximum cavitation rate and almost directly proportional to the breakdown incubation period. This method was tried on valves cavitating behind the gate, made of cast 20MnSi steel, 14Cr17Ni2 steel, or 10Cr18Ni11Mo2TiAl (EP-987) austenitic-ferritic dispersion-hardened steel, with AMg-2 aluminum alloy as the reference material. Loss of mass was measured after up to 258 "cold" starts and up to 289 "hot" starts. An evaluation of the data and their verification against results of direct tests by a conventional method as well as against structural examination under an MSB-2 microscope have confirmed the validity of this method with appropriate piecewise-linear approximation of the cavitation kinetics. For the first time in Soviet design practice, it was thus possible to predict the cavitation resistance of a gate valve on the basis of such an accelerated test: approximately $\tau = 1500$ h life on the basis of $\Delta h_{max} = 30$ mm wear depth and a $\Delta h = 0.0195 \tau - 0.082$ mm relation for cast 20MnSi steel. Figures 7; tables 2; references 9: 7 Russian, 2 Western (1 in Russian translation).

DETERMINING CRITICAL POWER OF FUEL ASSEMBLIES IN RBMK-1500 MW WATER-GRAPHITE
CHANNEL REACTOR

[Article by L.L. Bronitskiy, A.N. Zastrogin, S.P. Kuznetsov, and
V.V. Postnikov]

[Abstract] The safety margin of fuel assemblies, which determines the
reliability of a water-graphtie channel reactor, depends on the critical
power for each channel corresponding to the dryout heat transfer. The
critical power is theoretically calculated by the method of successive
approximations, the channel power being increased stepwise until the thermal
flux density becomes equal, within prescribed accuracy, to the lowest
critical along the channel height. This critical thermal flux density is
largely determined by the nonuniform distribution of energy release over the
channel height, a consequence of heat transfer intensifiers being installed
in the upper part but not in the lower part of fuel assemblies, so that its
determination requires a complete thermohydrodynamic analysis. Practical
calculation of the critical power is based on an approximating analytical
expression which can be processed quickly and easily by the reactor control
computer. The critical power for fuel assemblies in an RMBK-1500 MW reactor
can be represented as a function of the coolant flow rate, the coolant inlet
temperature, the separator pressure, and the vertical (axial) energy
profile. Theoretical analysis and measurements indicate that the pressure
dependence is negligible over the 5.88-7.11 MPa range and, therefore, practical
calculations based on a separator pressure of 6.865 MPa will be correct.
The critical power thus becomes reduced to a function of only three arguments,
with the vector of harmonic coefficients normalized to the fundamental com-
ponent representing the axial energy profile. It can now be evaluated
numerically by matrix calculus, for nominal as well as other coolant flow
rates and temperatures, with the coefficients approximating that energy
profile having been validated by a Fisher's q = 5% significance test.
The thermotechnical reliability of the reactor core is then obtained from
the first partial derivatives of the critical power with respect to all
arguments. Figures 3; tables 1; references 6: 5 Russian, 1 Western
(in Russian translation).

DETERMINING TURBULENT DIFFUSION IN ROD ARRAYS WITH SODIUM AS COOLANT

[Article by K. Popescu and N. Danila, Institute of Nuclear Power Reactors,
Pitesti, Socialist Republic of Romania; L. Sabotinov, Y. Yordanov, and
N. Antonov, Institute of Nuclear Research and Nuclear Power Engineering,
Bulgarian Academy of Sciences, Sofia, People's Republic of Bulgaria]

[Abstract] The circumferential temperature distribution andtthus also the
maximum temperature in a reactor fuel assembly depend on the temperature
field in the corresponding cross-section for passage of liquid coolant
between the rods. For a determination of that field, relations describing
momentum transfer by turbulent radial and circumferential diffusion as well
as heat transfer by turbulent thermal diffusion are established on the
basis of thermohydrodynamic analysis. Using the method of lumped parameters
for this analysis makes it possible to extend calculations for a double-layer
annulus as mathematical model to a symmetric arrays of parallel circular
cylinders as model of a fuel rod assembly. The velocity profiles and the
transfer coefficients characterizing the turbulent diffusion are accordingly
obtained from the equations of momentum and energy conservation with
appropriate boundary conditions, taking into account friction in the liquid-
metal boundary layer. The diffusion pattern is found to depend strongly on
the array geometry, number and spacing of rods, much less on the Reynolds
number and on the position angle. Numerical results for liquid sodium as
coolant agree closely with experimental data and with results based on the
H. Ramm-K. Johansen phenomenological model. Figures 5; references 11:
1 Russian, 10 Western.

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POST-DRYOUT HEAT TRANSFER IN BILATERALLY HEATED ANNULAR CHANNEL

[Article by V.V. Sergeyev, O.V. Remizov and E.F. Galchenko]

[Abstract] Deterioration of the heat transfer during upward flow of a steam-
water mixture in a bilaterally heated annular vertical channel is analyzed
on the basis of experimental data, and as a basis for engineering calculation
of the post-dryout heat transfer. The experiment was performed in a high-
pressure test stand with forced water circulation at flow rates of 300-865
kg/(m^2·s) under pressures of 9.8-17.8 MPa for cooling purposes. The annular

channel, 2 mm wide and 3000 mm high, was formed by two tubes of 12Cr18Ni10Ti steel. The vessel (32 mm inside diameter, 3 mm wall thickness) and the rod (28 mm outside diameter, 2 mm wall thickness) were electrically insulated for independent heating with alternating current of 50 Hz (commercial frequency). The thermal flux density was in this manner varied over the 35-450 kW/m^2 range at the vessel surface and over the 20-400 kW/m^2 range at the rod surface. A uniform channel width was maintained by means of symmetric triads of conical BeO spacers and cylindrical BeO pins alternating in 165 mm steps along the channel height. Temperatures were measured with Chromel-Alumel thermocouples also symmetrically placed around the channel at various heights. Their readings have been used for determining the dependence of the critical steam content in the cooling water on the power input to the outer channel wall at various coolant flow rates. This relation, combined with the energy equation for upward flow of a two-phase stream, yields the parameters of heat transfer after dryout more accurately than do conventional empirically established equilibrium relations. These parameters are essentially determined by the temperature of the nonequilibrium superheated steam and the transfer characteristics of the two-phase stream. For engineering purposes, they can be calculated on the assumption that the stream is homogeneous monodisperse, that heat is dissipated from the hot surface by forced convection of superheated steam, that evaporation of water droplets at the hot surface is negligible, and that the Nusselt number for those droplets is constant within the post-dryout region. Such calculations yield for the empirical constant, coefficient in the energy equation, $C = 1.75$ m^3·s^2/kg^2 when dryout occurs simultaneously at both hot surfaces of a vertical annular channel. Figures 6; references 8: 6 Russian, 2 Western.

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BASIC PREMISES IN DEVELOPMENT AND REGULATION OF SYSTEM FOR MANAGING ENERGY PRODUCTION

Moscow ELEKTRICHESKIYE STANTSII in Russian No 2, Feb 86 pp 2-6

[Article by V.I. Ilich, candidate of economic sciences, and V.S. Fiantsev, engineer, All-Union Scientific Research Institute of Nuclear Electric Power Plants]

[Abstract] Better planning of energy production is needed for a more effective growth of the national economy. This requires efficient management of operations and expansion at both power plant and power grid levels. A set of premises for development of such a management system is proposed, these premises being essentially methodological ones. They are: logical and rational organization of target-oriented technical and economic planning with the aid of models, using control theory and computer simulation for their optimization; norm setting and documentation; monitoring plant operation and

construction for cost effectiveness; and monitoring and evaluating performance of grid supervision, plant supervision, and work force. These premises have been established on the basis of studies covering three nuclear electric power plants (Kursk, Kola and Beloyarsk) and have been used in setting up such a management system for those plants. Another premise is that improvements in managing energy production will be consistently sought in a continuing development process. Figures 1; tables 3.

DYNAMIC CHARACTERISTICS OF STEAM GENERATORS IN POWER GENERATING UNIT WITH VVER-1000 [WATER-MODERATED WATER-COOLED 1000 MW POWER REACTOR] AS OBJECT OF LEVEL CONTROL

[Article by O.N. Pavlysh, engineer, and Yu.N. Reukov, engineer, Southern Regional Engineering Administration of Power System Management]

[Abstract] Automatic level control of steam generators in nuclear power plants such as those with a VVER-1000 [water-moderated water-cooled 1000 MW] reactor must satisfy stringent requirements, proper operation allowing not more than a ± 50 mm deviation from the nominal water level. A drop by more than 300-500 mm will trigger cutout of the main circulation pump and shutdown of the power generating unit after a 15 s delay, a rise by more than 500 mm will trigger closure of feedwater and steam bleeder valves. Unlike conventional drum-type boilers, these steam generators have a small water volume, a large evaporation sufface, and a nonuniform vertical profile of steam quality. Determination of their dynamic characteristics and responses to the various perturbations occurring in the system was necessary, for the purpose of optimizing the design and the setting of their level regulators. They were accordingly tested under transient conditions during perturbations of the feedwater flow, of the turbine regulating valves, and of some reactor control rods, also after cutout of the main circulation pump and after load dropping from the turbine. The results indicate that the water level in these stream generators can rise by 125-150 mm after load dropping or cutout of the main circulation pump. Regulators operating in accordance with the 3-pulse scheme are adequate, but their performance can be improved by using the coolant temperature rise in the primary loop rather than the feedwater level as the driving signal or by attentuating the steam rate signal so as to increase the regulator sensitivity to "swelling" of the water level. When one of the two turbine-driven feed pumps cuts out during down-loading of the power generating unit, because of initial water shortage, then large dips of water level in the steam generator can be prevented by fast and matched down-loading of both turbine and reactor. Figures 3; references: 2 Russian.

METHODS OF IMPROVING VARIABLE LOAD PERFORMANCE OF STEAM PRESSURE CONDENSER
OF NUCLEAR POWER PLANTS WITH WATER-MODERATED, WATER-COOLED POWER REACTORS

[Article by A.S. Korshunov, engineer, and B.K. Maltsev, candidate of
technical sciences, All-Union Thermal Power Engineering Institute
imeni F.E. Dzerzhinskiy]

[Abstract] The pressurizer produces and maintains the proper pressure in the
cooling loop of a power reactor, limits pressure transients and protects the
system against accidental overpressures. It is connected to the cooling loop
with two pipes: a breather pipe joining the lower part of the pressurizer
to the hot line from the loop and an injection pipe joining the top to the
cold line of the loop. Extensive operational experience has shown that in
conventional variable load modes, coolant flow and temperature differences
between these two lines can produce a thermal shock and frequent temperature
fluctuations due to load changes can reduce the strength of the system. It
is possible to reduce the thermal stresses by preventing the surging of the
medium in the bottom connecting pipe. This is accomplished by feeding cold
water into the steam space of the pressurizer and using electric heaters to
maintain a constant pressure. This paper adduces simple design equations for
such a system; these equations were used to calculate the rate of change of
coolant volume in a loop for which there is no surging of the medium in the
lower branch pipe of the pressurizer in AES power units with VVER-440 and
VVER-1000 reactors. These volumetric rates of change were 32.7 m^3/hr for
the VVER-440 and 56.7 m^3/hr for the VVER-1000 reactor, which corresponds to
a reactor power change of more than 6% per minute. The proposed method
is effective only in the case of planned power level changes. Figures 1.

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CHOICE OF STEAM PARAMETERS FOR TESTING CENTRIFUGAL SWITCHES OF OVERSPEED
GOVERNOR OF K-300-240 KhTGZ TURBINE

[Article by I.P. Danilyuk, Yu.N. Khaustov, and L.G. Khaustova, engineers,
Zuyevsk GRES-2 and Donets Technical Power Administration]

[Abstract] Steam flow through the K-300-240 KhTGZ turbine (Kharkov Turbine
Generator Plant imeni S.M. Kirov) must be limited during testing of the
centrifugal switches of the overspeed governor to preclude damage to the
turbine in case the control valves are fully open for some reason. Steam
flow control is easily accomplished when there are bypasses around the main
stream stop valves, though when such bypasses are lacking or have a low
capacity, the Kharkov plant recommends that the main stream stop valve itself
be used for flow limiting. This is difficult because of practical problems in

setting the requisite position of the valve. The Donets Technical Power Administration in conjunction with the Zuyevka GRES-2 has developed a simpler method of steam flow limiting for testing purposes when there are no bypasses. This is accomplished by choosing the initial steam pressure ahead of the stop valve of the high pressure cylinder when the main stream stop valve is fully open and the turbine is running at 3000 r.p.m. so that the full openingoof the turbine control valves is reached when the speed goes to 3360 r.p.m. This initial steam pressure is a function of the pessure in the condenser and governs the steam rate of flow through the turbine at 3000 r.p.m. with the control valves fully open. By knowing the steam rate of flow through the turbine as a function of the rotor r.p.m. for various values of the pressure in the turbine condenser, as well as the change in the steam rate of flow as a function of the opening of the control valves, the initial steam pressure ahead of the high pressure cylinder stop valve can be found for 3000 r.p.m. The steam rate of flow for a fixed r.p.m. is determined by experiment and calculations from the averaged values of the turbine efficiency, which are summarized in a table in this paper for speeds of 2500 and 3000 r.p.m. at pressures in the condenser of 0.0108, 0.00637 and 0.00343 MPa. A nomogram is given for the determination of the live steam pressure ahead of the turbine at 3000 r.p.m. for the above three condenser pressures. This method of limiting the steam flow allows more reliable and less labor intensive testing of centrifugal overspeed governor switches. Tables 1; figures 1.

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STELLARATOR RESEARCH PROGRAM AT INSTITUTE OF GENERAL PHYSICS (USSR ACADEMY OF SCIENCES)

[Article by L.M. Kovrizhnykh, doctor of physico-mathematical sciences]

[Abstract] The stellarator research program at the Institute of General Physics is a part of the overall research program concerning thermonuclear fusion and deals, specifically, with containment of high-temperature plasmas in closed magnetic traps. Although this program was started simultaneously with the tokamak research program, it is now about 5-10 years behind in terms of development. A comparison of a stellarator (conceived in the USA) and a tokamak (conceived in the USSR) indicates why constructing a stellarator is more difficult. The main problem is producing a helical magnetic field, which requires a special configuration of current conductors. The three basic advantages of a stellarator are feasibility of its steady-state operation, absence of Joule-effect heating with consequently higher plasma containment stability, and availability of the special magnetic field as a natural diverter for removal of impurities from the plasma periphery. Already about 20 stellarators exist in the world now, including two built in the USSR: "Liven-2" (Institute of General Physics) and "Uragan-3" (Institute of Chemical

Physics and Technology). Studies made at the Institute of General Physics have revealed that the magnetic structure of a stellarator is highly sensitive to resonant perturbations, which can result in complete breakdown of the magnetic surfaces with an attendant higher plasma leakage from traps. Producing a stellarator magnetic field with an array of discrete current coils has also been proposed here. Conservative theoretical estimates of the maximum attainable ratio of plasma pressure to magnetic induction squared have already been exceeded in experiments. Further studies of stellarator physics will aim at attainment of still higher ratios, delve into transfer processes during rare neoclassical collisions and transfer processes in peripheral plasma regions with a possibly anomalous thermal conductivity, also into the effect of Joule heating and other heating mechanisms on the plasma containment parameters. Another important subject of further studies will be high-frequency heating of a plasma by means of electron-cyclotron or ion-cyclotron resonance and particularly efficient first-harmonic heating of ions, the possibility of which was discovered at the Institute of General Physics. Figures 3; tables 1; references 7: 3 Russian, 4 Western.

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CONFERENCE DISCUSSES YAMAL DEVELOPMENT

Moscow GAZOVAYA PROMYSHLENNOST in Russian No 3, Mar 86 p

[Article: "Yamal: Scientific-Practical Conference at Mingazprom", underlined passages enclosed in slantlines]

[Text] The future comprehensive development of hydrocarbon fields in the Yamal Peninsula was a theme for detailed discussions at a scientific-practical conference organized by Mingazprom [Ministry of the Gas Industry]. Four hundred-fifty scientists and specialists participated. These included: academicians, candidates and doctors of science and well known researchers on the country's northern regions.

The conference assisted in working out strategic directions in the comprehensive development of hydrocarbon deposits in the Yamal Peninsula. It stated that a basic goal was the examination and solution of questions in the timely preparation for solving tasks in the exploitation of oil and gas resources in which construction organizations and machinery building enterprises are to play leading roles.

Representitives from the following participated in the scientific-practical conference: CPSU Central Committee, USSR Council of Ministers, RSFSR Council of Ministers, USSR Gosplan, RSFSR Gosplan, USSR Gosstroy, GKNT [State Committee on Science and Technology, Gosgrazhdanstroy [State Committee on Civil Construction], party and soviet organs in Tyumen Oblast, prominent scientists and specialists in the USSR Academy of Sciences and the Ukrainian SSR Academy of Sciences, the Central Committee of the Trade Union of Gas and Oil Industry workers and ministries and departments. It was opened by the first deputy minister of the Gas Industry, who spoke on the theme: "Basic Problems in the Comprehensive Development of Oil and Gas Resources in the Yamal Peninsula." Participants at the session heard a large number of reports and comments on various aspects of exploiting the peninsula's hydrocarbon reserves; schemes for the development of Yamal's oil and gas industry up until the year 2000, the state and prospects of raw material base development, ways of intensifying the exploration for local construction materials and supplying projects with water for process and commercial-domestic needs; basic technical solutions in the development and completion of fields and in the extraction and transportation of products; methods of laying various types of pipelines

in extreme arctic conditions; the development of transportation services for work on the peninsula, the creation of infrastructure and problems in protecting workers' health.

It was noted at the conference that /the use of traditional methods/ of development with independent networks of wells and the simultaneous operational introduction of fields in this region is /ineffective/ because this would require the preliminary construction of DKS [not further identified] at the beginning of development, the construction of various independent arrangements for gas collection, a large number of wells, etc. /It is therefore necessary to examine new approaches/ to the development of deposits, involving the creation of highly efficient arrangements for the exploitation of complex multibed systems, solutions to questions in the creation of reliable designs for wells in permafrost, and also research on the possibilities for maximum concentration of wells in clusters, using slant hole directional drilling, the creation of effective drilling fluids, backfilling cements and pipe insulators to compensate for permafrost.

Basic directions in scientific and technical progress in the development of arctic zone fields found reflection in solutions at the scientific-practical conference.

Recommendations were made on the basic engineering solutions for opening up the Yamal Peninsula fields: gas extraction and preparation for transport, the construction of production and residential structures. In the opinion of conference participants it is advisable to create an intersector scientific-technical program for the comprehensive opening of the peninsula's oil and gas fields, and, during 1986-1990, conduct the needed experimental research on various conditions in the Yamburg field.

It was deemed necessary that during work on questions involving the accelerated opening of the peninsula's gas and oil fields wide use be made of modern scientific and technical achievements and progressive experience from gas and oil fields in West Siberia and other regions in the country.

Placing exceptional importance upon comprehensive and coordinated efforts of ministries, departments and organizations participating in the opening up of the Yamal fields, the conference compiled a list of questions requiring top priority solution.

Conference materials will be published in the next issue.

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TECHNO-ECONOMIC ANALYSIS OF REACTIVE POWER COMPENSATION DEVICE

Moscow GAZOVAYA PROMYSHLENNOST in Russian No 3, Mar 86

[Article by N.N. Khaylov and Ye.B. Bochkarev [MING imeni I.M. Gubkin, Orenburg Polytechnic Institute]

[Text] Gas industry enterprises use various sources of reactive power to compensate for reactive power in electrical power grids, increase the power factor and maintain constant voltage. Their comparative techno-economic analysis shows that brushless excitation have advantages in such compensation and have lower unit costs.

Various sources of reactive power were compared for the following indicators: unit costs for the production of 1 kvar of reactive power;
unit losses of active power in the production of 1 kvar of reactive power;
outlays of active power to produce reactive power at the source's rated working conditions.

As they are the most widely used in the gas industry, 5,000 and 6,300 kW synchronous motors with thyristors and brushless excitation, and static capacitor type UKNP-38 batteries were selected for comparison.

The results of techno-economic studies are given in the table.

Source of reactive power	Unit costs rubles/kvar	Unit losses kW/kvar	Outlays of active power kW
Synchronous motor, 6,300 kW, 3,000 rpm with brushless excitation	21,190	0.0078	40.09
Synchronous motor, 6,300 kW, 3,000 rpm with thyristor excitation	21,197	---	---

Source of reactive power	Unit costs	Unit losses	Outlays of active power
Synchronous motor, 5,000 kW, 375 rpm with thryristor excitation	rubles/kvar 29,450	kW/kvar 0.0155	kW 64.40
UKPN-38 static capacitor batteries	44,600	0.0045	0

The table shows that all indicators are considerably better for synchronous motors rotating at 3000 rpm. This supports the conclusion that it is more economical to use higher speed synchronous motors than slower speed ones.

Of all the synchronous motors with various excitation systems used as sources of reactive power, preference should be given to those with brushless excitation. These motors, having the same power as those with thyristor excitation, have lower unit costs to produce 1 kvar of reactive power. True, according to the table the difference is not great, amounting to only 0.7 kopecks. However, at large volumes of reactive power it becomes significant. For example, by using brushless instead of thyristor motors at the Orenburg Helium Plant alone the annual savings could reach 80,000 rubles.

Costs for the production of 1 kvar of reactive power by static capacitors are not quite one-half those for synchronous motors. This is because synchronous motors at gas industry enterprises are acquired mainly for process work and therefore outlays for using their compensating capacity are not great. Static capacitors are installed only to compensate for reactive power.

In addition, synchronous motors have a number of qualitative advantages: they can quite simply handle changes in the magnitude of reactive power put into the system and can therefore be smoothly regulated. Static capacitor batteries usually do not support changes in reactive power and in order to obtain variable reactance they must be equipped with expensive special regulation devices.

As sources of reactive power synchronous motors are sufficiently stable in working with fluctuating voltages and with transients (sharp drops in voltage) their reactive energy output increases, helping to stabilize voltage. On the other hand, the generation of reactive power by static capacitor batteries is sharply reduced when voltage drops, as it is proportional to the square of the voltage. This leads to an even sharper drop in system voltage.

However, static capacitor batteries do not lose much active power in the production of 1 kvar. Active power consumption is several times lower than when synchronous motors are used. This is because when producing reactive power static capacitors use practically no active power, i.e. active power consumption is practically equal to zero. When active power is produced by synchronous motors, they can become overexcited and the power for their excitation increases. Therefore, power losses and consumption are considerably

greater.

As is known, one of the substantial advantages of static capacitor batteries is the possibility of improving electric power quality, in particular, by reducing the nonsinusoidal forms of current and voltage in the system. Therefore, their inclusion in the system to compensate for reactive power, provides for the "filtering out" ["otsos"] of higher harmonics of voltage and current, thus improving their form. The current's higher harmonic distortion factor, defined as the ratio of higher harmonics to all harmonics in the current curve, declines sharply. However, experimental research shows that similar phenomena are observed when synchronous motors are used to compensate for reactive power. These motors also have the capability of "filtering out" higher harmonics. The dependence of the higher harmonic distortion factor upon excitation current obtained during experiments at the Orenburg Helium Plant supports this. These experiments show that when synchronous motors are overexcited, i.e. when they are compensating for reactive power, the higher harmonic distortion factor declines sharply. This capability depends upon the motors' active power load. Reductions in motor load are more helpful in reducing the presence of higher harmonics in the system and thus sharply change the harmonic factor.

Therefore, synchronous motors should be used to regulate voltage and compensate for reactive power at industrial enterprises. Preference should be given to synchronous motors with brushless excitation as they are more advantageous economically.

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URAL HEAVY MACHINERY PLANT TO INCREASE OUTPUT OF DRILLING EQUIPMENT

Moscow PRAVDA in Russian 16 Mar 86 p 2

[Article by V. Danilov and V. Reut, PRAVDA special correspondents, Sverdlovsk*: "Start into the Fugure. Fulfilling Resolutions of 27th CPSU Congress"]

[Text] The "Uralmash" [Ural Heavy Machinery Plant] Production Association is the main supplier of drilling equipment for the West Siberian Oil and Gas Complex. It completed the last year's plan for the deliveries of drilling units and pumps. This year, 125 drilling units must be manufactured for the organizations of the Tyumen Oblast. Forty-five units must be completed during the first four months, which requires great efforts of the workers of the "Uralmash".

Since further development and technical reequipment of the West Siberian Oil and Gas Complex is a multilevel problem whose solution depends not only on "Uralmash" but also on many of its related industries, as well as on other organizations, a meeting of the oblast party active members was held in Sverdlovsk in February. The first secretary of the CPSU Oblast Committee, Yu. Petrov mentioned in his report that 82 enterprises and associations of the oblast supply their products to various organizations of the oil and gas complex of West Siberia. He said: "We have the right to be proud of the oblast's contribution to the development of the oil and gas complex. However, it means that the difficulties which are experienced today by the Tyumen oilmen are also our concern and, to a certain degree, the consequence of our inadequate work".

The meeting of the active party members confirmed once again the necessity of complete and early fulfillment of all orders of the oil and gas complex.

First Steps

"Uralmash", of course, is taking measures for improving the quality of their drilling equipment, lowering labor intensity of its manufacturing and successfully handling the increased tasks. The personnel of the association understands perfectly that such are the demands of the time. What was considered sufficient yesterday is appraised more exactingly today. The workers are not complaining about the difficulties. The equipment in the shops is checked and technological processes are improved with special devices in order to improve the stability

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*Continuation. Beginning in PRAVDA, March 16

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of the quality of the parts. New technological processes are introduced: plasma cutting of rolled steel on machines with numerical program control, electron-beam welding of cyclinders of drilling equipment, plasma surfacing of the rods of mud pumps and others. Incoming quality control of components and assemblies of drilling units is being organized.

The personnel of the enterprise is well informed of the stepped-up plans of work in the new five-year-plan, particularly during the first year. Whoever we met, realized that they have to work hard. These are the goals of the resolutions of the 27th CPSU Congress.

We visited one of the mechanical shops where parts of dilling and excavation equipment are machined. We walked through the shop together with its superintendent, V. Korovin. Metal cutting machines are of various dimensions and purposes, since the configurations and dimensions of the parts are different. However, we were surprised by something else: the appearance of some machines was quite "elegant" and good enough to be exhibited, while others were very unattractive. Some others were so worn out and far from modern designs that, it seemed as if they were just brought from a history of technology museum.

According to V. Korovin, this had to do with the "age structure" of their machines. Some of them are almost as old as the plant itself, which is over 50 years old.

We approached two identical machines with NC [numerical control].
One of them was working, but the other was standing still and the operator was trying to repair it.

"Poor man", V. Korovin nodded in his direction. "He operates both of these machines... they were the first ones with numerical program control and operated very efficiently. However, they are far beyond their rated service life."

We asked if the plant equipment is being updated.

V. Korovin said that it is. However, so far approximately 2-3 percent of the equipment was updated every year. In his opinion, a minimum of eight or nine percent of equipment should be replaced every year, otherwise the plant will not be able to keep up with the technical progress.

We mentioned that they will have to manufacture parts of some new equipment.

According to V. Korovin, there are also some other difficulties with the production of new equipment. Usually they have to manufacture 2-3 new machines a year. Their production technology is not yet worked out, they do not have the necessary equipment, and only approximate norms are given for them. Under these conditions, the workers have to use their own resourcefulness in manufacturing individual parts. This is not easy and requires additional work and time. As a result, the workers lose in their wages and are not materially interested in this work. In his opinion, some increment factor should be established for putting a new machine into production until it goes into series production. It is particularly important because their stock of machine tools is still quite inadequate.

The situation there is not too good. Let us take only two figures: in the machine shops where the machining of parts for drilling and excavation equipment is concentrated, only 13% of metal-cutting machines are up to five years old, while about 30% are more than 20 years old. But even among those which are less than 20 years old, there are quite a few that have to be replaced.

Of course, this situation could but worry the management of the enterprise and its service departments. Last year it became already clear that the difficulties and shortages they have to put up with for so long cannot be tolerated in the 12th Five-Year-Plan. A plan for technical reequipment of the entire large-scale series production is being developed jointly with the institute "Uralgiprotyazhmash" [Ural State Institute for the Planning of Heavy Machinery Plants]. It is planned to introduce overall mechanization and automation of production processes, including fully mechanized sections, lines and shops, install program-controlled equipment, to use robot complexes and many other things.

However, in the first year of the five-year-plan, the Tyumen workers will still be receiving equipment without the comfortable conditions provided in its new modifications. The production of units with heating facilities, probably, will not go beyond the two experimental specimens, which is a pity. Units which are more convenient in operation and maintenance, are more reliable and make the work of drill operators easier are needed without delay. It is very important to speed up the organization of their production as much as possible.

It is gratifying to see that creative ties of the workers of "Uralmash" with the consumers of its products are increasingly strengthening. An important role in this respect is played by the agreement concluded at the end of last year about scientific and technical cooperation between the production association "Uralmash" and Glavtyumenneftegaz [Main Administration of the Tyumen Oil and Gas Industry] for the years 1986-1990. This agreement is already in force. A maintenance service for drilling equipment is being organized on its basis in Nefteyugansk. Many problems occurring in the course of the operation of drilling equipment connected with its repairs will be solved on the spot.

At a Higher Level

Two main problems are to be solved by the personnel of the "Uralmash" association for the development of production and raising the technical level of drilling equipment for West Siberian Oil and Gas Complex: to set up and increase the production of drilling units of the 3000 EUK-IM-type and the three-piston mud pump UMBT-950.

For the time being drilling units will be manufactured in the same shops as today, although the latest technological processes and equipment will be used. This updating will be done without stopping their production.

Welded structures constitute a large part of drilling equipment. They are produced by the plant of welded machine-building structures in the city of Verkhnyaya Pyshma which belongs to the "Uralmash" association. The plant is not yet completed, and new production capacities have to be put into operation there

next year. However, there are doubts whether or not electrical welding equipment will be supplied on time by the enterprises of the Minelektrotekhprom [Ministry of the Electrical Equipment Industry].

The reliability and efficiency of drilling units depend greatly on the quality of components supplied by related industries. These are diesels, electric drives, automatic devices, chain drives, ball bearings, and many other items. Enterprises manufacturing them must also be fully responsible for the technical level of their products in order to avoid additional difficulties for the drilling people.

Next year, the first section of the UMBT-950 mud pump shop producing 360 such pumps must start operating at the Bulanash Machine-Building Plant, which also belongs to the "Uralmash" association. By the end of the five-year plan, they will be producing 1,230 pumps a year. It will be a highly mechanized plant with flexible automated lines, with built-in facilities for thermal treatment, and hardening of parts, including the nitrogen case-hardening and deep chrome plating, or in short, widely using the modern achievements of science and technology. However, not all problems pertaining to deliveries of equipment have been solved there too.

During the years of the 11th Five-Year Plan, the Scientific Research Institute of Heavy Machinery completed a large-scale scientific and technical project on the study and development of new drilling units. Efforts are made in the shops of the enterprise and the association as a whole to use the results of their work as much as possible, improving the equipment and production technology. The members of the association are becoming more and more confident that the work conducted today will make it possible to completely update their products list of drilling equipment and achieve the highest quality rating of all their products which have to be certified in the 12th Five-Year Plan.

The work connected with the fulfillment of jobs for the West Siberian Oil and Gas Complex is being controlled by the shop party organizations and the "Uralmash" party committee. There are specially created committees on technological progress and new equipment, on the quality of products and on labor and production discipline. The problems of the quality of manufactured machines and the improvement of production efficiency are regularly discussed at conferences and seminars of secretaries of the party organizations. All this contributes to the mobilization of the personnel of the association for the fulfillment of those tremendous tasks which were set by the resolutions of the 27th CPSU Congress for the party and the people and every Soviet worker.

Speaking at the meeting of the oblast active members of the party, I.Stroganov, general director of the production association "Uralmash", said:

"We treat the tasks set for our personnel with a sense of deep responsibility. In this five-year plan, we expect to improve the quality of mud pumps and are developing more advanced drilling units. And, although we have to encounter many problems, we shall fulfill our obligations to the Tyumen oilmen".

The "Uralmash" people have always kept their word.

10233
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STATUS OF AND OUTLOOK FOR MHD-PLANTS IN POWER GENERATING SYSTEMS

[Article by V.A. Kirillin, academician, A.Ye. Sheyndlin, academician,
G.N. Morozov, candidate of technical sciences, and A.S. Bryskin, engineer]

[Abstract] The main advantage of an MHD power plant is the absence of
rotating parts, which eliminates the problem of mechanical strength at high
temperatures and under high pressures. Its thermodynamic cycle is the same
as that of a gas turbine, namely adiabatic compression and expansion with
isobaric heat inflow and outflow, the essential difference being that energy
of the expanding gas is not converted into mechanical energy of the turbine
but directly into electric energy. Efficient operation of an MHD power
plant running on fossil fuel requires that the electrical conductivity of the
combustion products, the active medium, be at least 3-5 S/m. This is achieved
by injecting into the gas stream small amounts of an ionizer such as potash
and maintaining the gas at a temperature not lower than 2200 K, preferably
as high as 3000 K. The site of the Ryazan GRES has been selected for a
270 MW prototype MHD power plant on top of a 312 MW steam turbine, both
together forming a binary cycle. The turbine can operate alone, with the
MHD generator shut down, which allows a wide load regulation over the 35-
100% range. The fuel for the MHD power plant is natural gas and the
oxidizer is either plain air or air enriched with oxygen to a 27 wt.% O_2
content. The plant is organized into a gasdynamic channel with oxidizer feed
and an ionizer channel, also a water loop with storage. The plant equipment
includes a compressor, an oxidizer heater with catalytic converter for
abatement of nitrogen oxides, a direct-flow combustion chamber, a linear
MHD conduction generator with diagonal channel and split loops for current
regulation, and with liquid-helium cooling of the superconductor windings,
an inverter substation with two 400 MVA transformers and a 500 kV outdoor
distributor, 220/10-10 kV and 20/6-6 kV transformers for feeding power
from the existing 220 kV outdoor distributor to plant auxiliaries, and a
water circulation system for cooling. The special turbine and boiler
auxiliaries include an afterburner, a mixer for reducing the temperature of
the main gas stream from 950°C to 800°C by injection of reduced gas at
340°C so as to prevent sticking of ionizer on pipe walls, a condensing
turbine which drives the feedwater pump independently of the main turbine,
a 3 MW electric standby pump for emergency boiler cooldown, and a direct

water channel from pump to boiler bypassing the pilot static head and thus immune to failure of the latter. This first MHD power plant should yield 16% advantage in fuel economy over a steam-turbine plant of the same rating under the same conditions. Furture commercially built MHD power plants will differ from the Ryazan prototype. Replacement of a single large unit with four smaller ones will reduce the unit cost of equipment, the air distributor and the intermediate compressor cooler will be eliminated, flue gases will be utilized for heating the oxidizer and feedwater will be tuilized for cooling. Most intricate but also most economical is utilization of flue gases not only for generating steam and heating the oxidizer but also for thermochemical processing of the fuel through endothermic reactions such as $C + CO_2 + 170$ kJ/mole = $2CO$ and $C + H_2O + 125$ kJ/mole = $CO + H_2$. The next step will be development of an MHD power plant running on solid fuel such as coal. A plant of this kind using Kuznetsk coal is already being designed. Figures 8.

2415/9835
CSO: 1861/218

HEAT TRANSFER IN COMBUSTION CHAMBERS OF U-25 MHD PLANT RUNNING ON NATURAL GAS

[Article by A.G. Rotinov, candidate of technical sciences, S.A. Tager, candidate of technical sciences, V.N. Sukhov, engineer, and N.A. Minyayev, engineer, Institute of HIgh Temperatures, USSR Academy of Sciences]

[Abstract] Heat transfer measurements were made in two combustion chambers for a U-25 MHD plant, a KS-B cylindrical low-capacity chamber (plasma rate 2.5-5 kg/s) with one combustion zone and a KS-3 conical intermediate-capacity chamber (plasma rate 25-50 kg/s) with two combustion zones. The ionizer, aqueous 50% K_2CO_3 solution, was injected into each chamber through pneumatic nozzles radially from behind the burners. The lateral walls were shielded by horizontal hollow copper busbars with cooling water inside and with 50 mm thick ZrO_2-ceramic panels filling the spaces between them, 107 mm wide along the KS-B chamber and 26 mm wide along the KS-3 chamber. Inlet and outlet temperatures of the cooling water were measured accurately within 2% with thermocouples, the water flow rate was determined accurately within 3% with a throttling flow meter from the pressure drop across a standard diaphragm. Complete fuel combustion and 90% final ionizer evaporation could be assumed on the basis of test data. Subsequent calculations were made by the IVTAN (Institute of High Temperatures, Academy of Sciences) method developed by the authors for radiative heat transfer and by the Kutateladze-Leontyev integral method for convective heat transfer, the latter in the approximation of a plane boundary layer and with correction for real values of the Reynolds number, except in the recirculation zones adjacent to the ceramic panels by the V.V. Koshkin method. Thermal fluxes at the ceramic panels

were obtained by solution of the two-dimensional equation of heat conduction by the method of separation of variables. These calculations were made on the basis of instantaneous combustion as well as 4 ms and 8 ms combustion time, actual measurement of it being very difficult, covering the entire practical range for natural gas. The results indicate that this procedure yields sufficiently reliable data needed in the design of combustion chambers for MHD plants. Figures 4; tables 2; references 8: 7 Russian, 1 Western.

BASIC SCHEME AND LAYOUT OF BOILER PLANT AND SOLAR HEAT COLLECTOR FOR HIGH-CAPACITY SOLAR-FUEL HYBRID POWER PLANTS

[Article by D.L. Itman, engineer, Special Design Office, All-Union Institute of Heat Engineering]

[Abstract] Solar-fuel hybrid power plants are preferable to solar power plants operating alone, inasmuch as they do not depend on the weather as well as on regular variations of collectable solar radiation. It is not necessary, however, to install a single dually heatable steam generator on top of a high tower for maximum advantage. It is also possible to use a standard boiler on the ground and a separate solar heat collector on top of the tower. Such an arrangement has been designed and laid out for a 300 MW power plant. It has a model TGMP-344 boiler heated by gas or oil, generating steam at a rate of 1000 t/h under a pressure of 25.5 MPa at 545/542°C, and a 250 MW cavity-type solar heat collector. During sunshine the full primary steam is passed through boiler screens to the solar heat collector and from here to a steam-to-steam heat exchanger, whereupon it returns to the boiler after having transferred some of its heat to the secondary steam. For maximum fuel economy and maximum steam temperature stability, with the fuel rate automatically adjusted to fluctuations of solar radiation intensity, the plant should operate under the maximum possible electric load. Calculations indicate that as much as 35% of natural gas can be saved without loss of steam rate or drop of steam temperature from respective nominal levels. A heat exchanger without secondary steam generator simplifies the overall construction and raises the thermal efficiency of the power cycle, both hydraulic and heat losses being reduced by elimination of some piping. The distance between boiler and solar heat collector should be as short as possible so that the length of piping for the primary steam moving back and forth can be minimized too. The solar heat collector should be protected against atmospheric precipitation and against slowdown of its cooling in the absence of sunshine, preferably by means of automatic devices synchronized with the heliostats. In the design

work participated engineers D.L. Itman, Yu.A. Kharkin, Ye.V. Shukin, V.B. Dub, and Ye.D. Kruglyak. Figures 2; references: 1 Russian.

FACTORS DICTATING SELECTION OF INITIAL STEAM PRESSURE BEFORE GEOTHERMAL ELECTRIC POWER PLANTS WITH ONE OR TWO EVAPORATION STAGES

[Article by O.S. Naymanov, candidate of technical sciences, Central Design Office, State All-Union Trust for Repair of Power Engineering Equipment, Kharkov branch]

[Abstract] A major problem in the design of geothermal electric power plants is the lack of precise starting data on the initial state of the working medium. Particularly important is to determine beforehand the optimum steam pressure before the turbines or at the plant entrance. An analytical solution of this problem is proposed, considering the general case of a variable initial discharge rate of the thermal medium from wells, a variable coefficient of power loss for station auxiliaries, and a variable internal turbine efficiency, all depending on the initial pressure of steam entering the turbines. The method applies to a plant with wells producing superheated water rather than steam as the thermal medium, steam being generated in evaporators by sequential pressure dropping. The corresponding equation for the useful power is formulated for a plant with either one or two evaporator stages, considering thattthe flow rate of the thermal medium is determined by the change of pressure in the first stage and does not depend on the change of pressure in the next stages. This flow rate and all three coefficients in this equation, including the coefficient which represents the decrement of maximum specific turbine power associated with deviation of the pressure in the first evaporator from its optimum level, are evaluated on the basis of theoretical and empirical relations as well as experimental data. It is understood that a higher inlet steam pressure corresponds to a lower steam flow rate per kilowatt of electric power output and, under otherwise the same conditions, to a lower power required by station auxiliaries (circulation pumps, condensate pumps, main ejectors). This power, per kilogram of thermal medium, depends also on the temperature of the cooling water and on the rate of steam generated from the thermal medium but not on the pressure in the evaporator. With the total steam rate represented as a linear function of the inlet steam pressure, differentiation of the power equation yields the optimum inlet steam pressure. Only roughly, however, owing to the flatness of the power-pressure characteristic and requiring refinement on the basis of earlier established relations. Design curves for calculating the various coefficients and the optimum inlet steam pressure depending on the number of thermal wells and their operating parameters have

been plotted, with the aid of data applicable to the Pauzhetskaya Geothermal Electric Power Plant in the Kamchatka Peninsula and such plants outside the USSR using steam-water mixture as thermal medium. Figures 4; tables 1; references: 3 Russian.

COST-EFFECTIVENESS ASPECTS OF UTILIZATION OF NUCLEAR WATER-MODERATED, WATER-COOLED REACTORS IN POWER GENERATION SYSTEMS FOR COMPREHENSIVE OIL SHALE PROCESSING

[Article by A.I. Popov, professor and doctor of technical sciences, V.Ya. Onishchenko, candidate of technical sciences and A.V. Meshcheryakov, engineer, Saratov Order of Red Banner of Labor Institute, presented by Department of Power Engineering Economics and Organization]

[Abstract] Heat generation requirements for oil-shale processing necessitate the use of nuclear power to increase the end product yields and improve the economic indicators. Since water-moderated, water-cooled power reactors are the best developed at present, this paper analyzes three possible oil-shale processing configurations designed around such reactors in order to ascertain overall system feasibility and cost-effectiveness: 1) Nuclear process power generation system with a TK-450/500-60/3000 turbine operating in the condensation mode; 2) Nuclear process heat and power generating plant with the same turbine operating as a heat source; 3) Process power generation system based on a conventional heat and power plant using a R-40-130/31 turbine fueled by gas from pressurized oil shale gasification. The shale is assumed to be from the Savelyevskiy deposit and has the following parameters: W^P = 20%; A^P - 50.55%; carbonates = 7.84%; combustible fuel = 21.61% and Q^P = 7,000 kJ/kg. The second variant is most efficient in terms of both the thermodynamics and cost-effectiveness, having an exergetic system efficiency of 46.2% with 10.7 million tons of shale processed annually and normalized costs ranging from 91.42 to 134.22 million rubles annually. Synthetic gas and liquid fuel costs do not exceed present cost levels for fuel when shale costs are no more than 3.4 rubles/ton. These costs can be reduced through cost recovery from byproducts (CO_2, H_2S and phenols). The overall system power efficiency of a nuclear power plant increases from 31% when operated just as a nuclear power plant to 49% when incorporated in an oil-shale processing system. Tables 3; figures 4; references 4: 2 Russian, 2 Western.

IMPROVING COST EFFECTIVENESS OF JOINT FUNDING OF SCIENTIFIC AND TECHNICAL DEVELOPMENTS IN ELECTRIC POWER

[Article by Ye.M. Shabalin, candidate of economic sciences, Moscow Institute of Control and Management imeni Sergo Ordzhonikidze, V.B. Dmitriyev and R.D. Akashev, engineers, Main Administration of Ural Regional Power System Management]

[Abstract] Since 1982 a joint fund for scientific and technical developments in electric power is being set up centrally by the USSR Ministry of Energy and Electrification, regional power system administrations and industrial associations not having their own funds for these purposes. This arrangement is based on systematic planning, to ensure that such funding yields its share of return to annual output and that none of this fund will be diverted for other purposes. This method of funding has been found to be cost effective at the departmental level, but not at the regional level of energy management. Its cost effectiveness depends, moreoever, on the extent to which scientific research becomes production-oriented and thus on how strongly it will interact with the energy production industry. An analysis of the fund allocations is difficult, because of a lack of precise criteria and because of the major role played here by organizational factors. Accounting procedures are often misleading, since expenditures for scientific research are included in production setup costs in large enterprises, and production setup costs are treated as expenditures for scientific research in small enterprises embarking on new projects. In order to make this joint funding more cost effective, it is therefore necessary to dc it not only at the top ministerial level but also at the middle level of regional power system administrations. This partial decentralization will improve banking accounting procedures. Credit must be given for unscheduled developments, partial repayments can be made to the central fund, and financial incentives should be expanded so as to stimulate scientific as well as technical achievements.

FLEXIBLE SKYSCRAPER

[Article by A. Zherebkov, architect]

> [Text] There is no threat of damage from earthquakes and
> typhoons to this new universal building which was designed
> and built for the first time in Sochi. Due to the flex-
> ible joints of its structures, it is capable of withstand-
> ing much greater stresses than the conventional buildings.
> The building received a high appraisal from specialists,
> however, the work came to a standstill. Its designers...
> were fired.

Residential buildings developed for Sochi must satisfy very specific conditions.
Some of them are: summer heat and humidity, complex mountainous terrain with
landslide areas, seismic activity (as high as 8 on the Richter scale), large tracts
of very old trees which cannot be cut down, high cost of land, and ever-increasing
shortage of urban areas intended for housing construction.

In the Sochi branch of the zonal Scientific Research Institute of Experimental
Design, we developed design proposals for a universal multifunctional civic
building. This is a tower-type high-rise building with a central core of verti-
cal communication facilities. It solves the main urban development problems,
such as economical use of city areas,preservation of green spaces, and the
use of inconvenient areas with a complex terrain for construction. The lower
floors of the building will be occupied by social, cultural and personal services
enterprises, and the upper floors will be residential. There are no set rules
for the ratio of this distribution, and, if necessary, it can be used as a mono-
functional building, i.e., as a residential building, dormitory, hotel, hospital,
administrative institution, trade center, etc.

In the central core of the building, it is possible to have indoor gyms, recre-
ational facilities for children and adults, craft workshops, maintenance services
and multistory garages. It is possible to have open-air sports courts and re-
creation areas on the roof of the building.

The design of the building is original (Patent No 696 139). It is known that
each type of design has a rational application area. We intentionally used the
"eclectic" method, having taken the best features from the known types of struc-
tures and creating a certain hybrid design.

One-cast structures are good for constructing massive engineering structures taking large horizontal stresses, as well as in constructing grain elevators, silos and vertical elevator wells which do not have any floors, and, therefore, when building the walls, it is possible to use the method of continuous concreting in sliding casings. Constructions of one-cast reinforced concrete are relatively inexpensive, which gives them definite advantages in comparison with sectional constructions particularly in seismic construction and warm climate conditions which makes it unnecessary to have additional energy consumption for heating concrete during the winter period. But it is more complicated and time consuming to build them then prefabricated structures.

In the proposed building, the central core is buit from solid reinforced concrete to contain vertical communication facilities: the staircase, elevators and ducts. This is a rigid shaft which gives the building overall stability, absorbing horizontal seismic and wind stresses on it.

Frame constructions are used, as a rule, in buildings the architectural and planning solution of which require open spaces for stores, dining rooms, dance halls, etc. These qualities of frame constructions were used for the lower stories of our building.

Large-panel constructions are more economical than frame constructions and require less metal and labor in their construction (residential buildings, hotels, hospitals, administrative institutions, etc). Large-panel constructions were used in the upper stories around the rigid shaft, which will contain residential and other premises of cellular structure.

Buildings with a solid core and frame construction around it have been known for a long time. However, unlike the traditional rigid methods of connecting the framework and the core, the joints of wall panels and floor plates in our building, as well as the junctions of the floors to the rigid shaft are yielding (Pattent No 696 139) and flexible. In this case, the reliability of the frame constructions during earthquakes does not lower as in the first frame-type floors which were destructed by jolts in Karakas, Skoplya and Ashkhabad from excessive bending of the columns. In our building, the frame structures literally hold on to the shaft of the rigid core, encompassing it with its floors.

The yielding joints of individual builing elements and structures intensively disperse and absorb the energy of seismic oscillations and wind stresses.

The mixed shaft-panel-frame system is similar to a flexible willow tree which endures without breaking tornado winds which uproot powerful oak trees.

The redistribution of stresses in the structures of the building makes it possible to increase the number of stories in the building above the norm lowering the consumption of steel, labor input and the cost of construction and to increase the artistic expressiveness of the building by plastic articulation of its facade. Such buildings can be built in any seismic areas changing only the reinforcement and brand of concrete of the rigid core of the building.

All this is not only the assumptions and calculations. Specialists of the Tbil-ZNIIEP [Tbilisi Zonal Scientific Research and Design Institute of Standard and

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Experimental Designing] and the builders of Glavsochispetsstroy [Main Administration of Sochi Specialized Construction] designed and constructed such a building. Its lower floor is an open area. It has a coffee shop, sections for games and relaxation in the shade. Its 15 upper floors have 45 one-room and 75 two-room apartments. The apartments have a double exposure, which gives good illumination and angular ventilation. Each apartment is equipped with household cabinets and has summer accommodations.
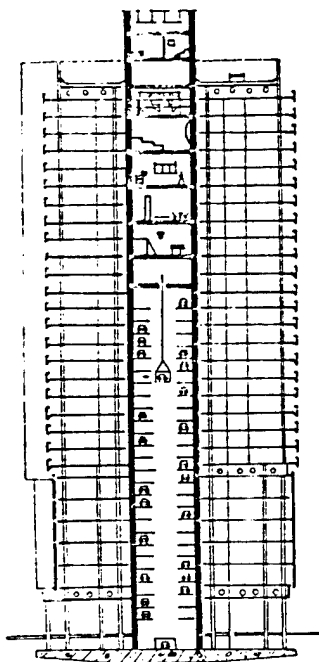
Sketch of "flexible skyscraper" with inside garage.

The central rigid core of the building has stairways, elevators and areas for drying the laundry.

This was the first experimental specimen of the building. It did not exhaust all of the potentialities contained in its design.

The program of tests of the structures of the building conducted by specialists of TbilZNIIEP and TsNIISK [Central Scientific Research Institute of Structural Parts] imeni Kucherenko confirmed the theoretical prerequisites adopted in the experimental design of the building. According to the data of TbilZNIIEP, there is a possibility of further lowering of the estimated cost by 15%, labor input by 20%, and consumption of steel by 35% in comparison with series-produced buildings constructed in Sochi.

But the result was: eight certified members of construction fields were fired, including all responsible members of the project of the experimental construction of the above building.

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Taking advantage of their geographical separation (the Sochi department is located in the RSFSR, and the main institute is in Tbilisi), the management of TbilZNIIEP is curtailing the work on this project. At the present time, the design of this building is being improved by heat-and-power engineers, machine-tool builders, peat workers and chemists. What good would there be from such "experts"?

However, such buildings can be built not only in Sochi and not only in seismic regions.

AIRCRAFT ENGINES USED ON GAS COMPRESSOR STATIONS

[Article by M. Umanskiy: "Aircraft Engines on Gas Pipelines"]

[Text] Our MI-8 flies over West Siberia. Everywhere, no matter where you look is a sea of taiga. From this height, of course, one cannot see the gas line, covered with a dusting of snow. However, we dropped lower and even though we tried, we could not find the steel pipes, almost 1.5 meters in diameter, which had been welded into a single line. Reliably protected from corrosion by a special covering, they had long been covered by a thick layer of earth.

In the helicopter, in addition to Russian, one heard English, French and German. As is known, in order to move the blue fuel along the Urengoy - Pomary - Uzhgorod export line, the Soviet Union considered it advisable to import some of the gas compression equipment. Of course, the foreign specialists could not help but be interested in similar units built by Soviet industry. Granting their wishes, the Ministry of the Gas Industry invited the managers of firms and a group of chief riggers working in West Siberia to take a get-acquainted trip to a number of compressor stations on the Tyumen gas pipelines. Kenneth Kerell [transliterated from Russian] Canadian and representitive of the consortium Mannesmann/Creusot-Loire, Donald Beveridge, an Englishman and plant manager for the John Brown firm, Henry Sharp, an experienced Scottish engineer and other specialists had already become acquinted with the newest 25,000 kW units produces by the Neva Plant imeni V. I. Lenin. The buildings in which these "muscles" for the pipeline were working, were in the background.

However, Kerrel, who was looking intently out the window, waved his hands, attracting our attention. And there was a suprise: Instead of the impressive compressor facilities standard for Urengoy, five small buildings stood in ranks on a small polyana in the taiga. There was a simple explanation for this: these were gas compressor units (GPA) of a fundamentally new design -- using 16 Megawatt aircraft engines.

One can understand the foreigners' increased interest in our little aircraft units ["aviamalyutki"]. After all, the Western press, especially during the American embargo, expressed abundant doubts as to whether or not the USSR

could build gas compressor units on its own. "The iron still must work", ["Zhelezo eshcho dolzhno zarabotat"], said BUSINESS WEEK.

The iron is already working. This is not surprising. A long time ago we began the program to use turbines which had outlived their flying time. The shift of the main effort in gas extraction to inaccessible and poorly developed regions in West Siberia located thousands of kilometers from customers gave rise to a large scale national economic task of building gas transport systems. One only has to point out that in roadless conditions just hauling construction materials and equipment for compressor stations is a very difficult problem. It became necessary to build and introduce gas pumping equipment which, being as small and light as possible, and with significant unit capacity, would not require the construction of special buildings, be distinguished by simplicity of installation and repair and also be highly effective and reliable.

Gas compression units powered by aircraft type engines best meet these requirements. The first 6.3 MW domestic machines were supplied to gas pipelines for experimental-industrial operation back in 1973. Today there are more than 700 such units, with a total power of 4,410 MW, working on the country's steel mainlines. This is 2.6 fold more than the total capacity of similar machines operating on gas pipelines in Western Europe.

However, in order to "teach" an aircraft engine to work efficiently on the ground after "going on pension", designers had to overcome a number of its "heavenly" peculiarities. In the final account success depended upon the extent to which they were able to optimally combine the "land and the sky"; that is, the characteristics of an aircraft engine with the demands made upon industrial compressor units.

Just what is a gas compressor unit with an aircraft engine? In its most general form this combines three machines into a single unit: a gas generator, a power turbine and an automatic system for controlling the entire unit.

Interestingly, design thought in our country and abroad has developed in two different directions. Western specialists placed their hopes upon the creation of power turbines meeting the standards and requirements of commercial gas turbine building. As a result, gas compressor units were designed for with power turbines and compressor sets having long service life between repairs (around 100,000 hours), but much shorter lived gas generators (25,000-30,000 hours). Turbine designs were such that all inspections, and the main thing, replacement of components, had to be made at the site.

Clearly, such a direction did not suit Soviet gas workers. A sizable number of gas pipelines pass through remote and unpopulated regions in Siberia and Central Asia. Just try to make any major repairs in the roadless tundra, taiga or desert. And what about spare parts supply? Experience in servicing stationary units shows that this sometimes takes months. Thus, the advantages of long operation between repairs are reduced to naught through long idle times.

This is why Soviet designers decided to give only the compressor long service life between repairs. It was considerable less for the drive (30,000-40,000

hours). Only the compressor is repaired on the spot, while the engine is sent to the manufacturing plant.

The second reason for the selection of aviation rather than industrial turbines was the possibility of extending the lives of engines which had flown out their time in the sky. Almost a decade's experience in the industrial operation of units with 6.3 MW aircraft engines shows the unconditional promise of such an economic approach. The introduction of the next generation 16 MW machines into the gas industry was a big step in the development of this very important sector. It not only opened the path for the use of modern aviation equipment and technology here, but helped introduce progressive solutions from other sectors.

One special feature of the new unit is that it is delivered to the site as completely in-plant assembled modules. Their is no need to build special buildings or covers. A concrete foundation is quite sufficient. We note that only aircraft equipment can provide such unique potentials for operating in the open in all winds and cold, at temperatures ranging from +45 to -55 C. The time required to build a compressor is cut roughly in half, labor intensiveness -- by 2.5-3 fold, concrete use by 2,600 tons and total metal intensiveness by more than half that of a stationary gas pumping unit of the same capacity. Reductions in installation time alone helps save the state up to 1.5 million rubles on each compressor station.

In order to compare the old units with the new ones, it is not necessary to travel 100-120 km from one compressor station to another, it is sufficient to walk 100 meters. All six transcontinental Tyumen pipelines were built in the same corridor. A compressor station is essentially a single site on which quite differently designed units are pumping for different lines. The construction of the multiline system thus became a unique test area for alternative designs.

Here is more evidence that monumental size is ceasing to be a symbol of scientific-technical progress. Compared to the three story installations housing 16,000 and 25,000 KW units, the containers housing aircraft engines seem almost toys. Nevertheless, the productivity of such units is quite high -- 33 million cubic meters of gas daily. Three such machines are sufficient to service a 1,420 mm diameter pipeline at a pressure of 75 atmospheres. However, there are 5 at a compressor station site, 2 are in reserve.

A fundamental solution to the repair problem -- this was the main advantage attained by the units' creators, who consciously sacrificed long term operation between repairs. Here are some not disinterested opinions about the new machine by those operating it on the gas lines. The words are those of Ye. Yakovlev, director of the Tyumentransgaz Production Association:

"The modular principle of installation to a great extent removed the agonizing repair problem from our shoulders. Any unit can be quickly disconnected and sent back to the factory. The most complex component -- the NK-16ST gas turbine engine, is mounted on a wheeled frame, so it can be rolled on rails in and out of the container. It only takes three days to completely disconnect it from the compressor and replace it with a reserve engine. An experienced crew can do this in a single shift. For comparison: an on the spot medium level

repair of a 10 MW unit takes, as a rule, at least a month, and this is if all spare parts are available. Where there are no roads it is also very important to note that the aircraft engine's light weight -- less than 8 tons, is fully within the capabilities of a MI-10 stub-winged helicopter. True, more often we use the MI-6 workhorse. It easily hauls a turbine or gas generator weighing about 4 tons each."

V. Kozachenko: chief of the Verkhnekazymskoye Line Production Administration:

"It has turned out that all our basic repairs are essentially reduced to the replacement of units or components which have broken down. It is no longer necessary to have a solid staff of highly qualified specialists and trouble-shooters at stations. Note the manufacturer's high technical standards. In addition to the gas compressor unit, the set of equipment includes attachments and special tools needed for the disassembly and assembly of components during repairs, and spares of quick wearing and especially precision parts. This is very important."

V. Bryzhakhin: chief of the Pravokhetinskoye Line-Production Administration:

"You know, this has always been my dream. I used to fly in a plane and think: what if the reliability of aircraft, with their irreproachable operation were applied to our gas pipelines, where all the compressor stations depend upon one another. If something happens to one, gas movement throughout the entire pipe is stopped. Millions are lost. And it was applied!"

Incidentally, this compressor station at Pravaya Kheta was also visited by Kenneth Kerrell, a veteran of this region who, for several decades, has been installing gas compressor units in Saudi Arabia, Iran, Iraq, Afganistan and other countries. He noted that a number of basic techno-economic indicators for the GPA-Ts-16 are equal to better foreign models, and some are better.

Today there are about 120 such machines, designed for a 75 atmosphere final pressure, operating on the Urengoy--Tsentr-1 and --Tsentr-2 lines. If necessary, they can be quickly and directly replaced and reequipped for 100 atmospheres.

In specialists' opinion there is an excellent future for this class unit. For example, they can be successfully used in the development of new processes for extracting oil and gas (the "cycling process" and gas lift), the expansion of underground storage of gas, the development of hydrocarbon deposits on continental shelves, gas fields with lower reservoir pressure and which contain valuable chemical (the Orenburg and Astrakhan fields, the gas of which contains sizable amounts of hydrogen sulfide).

We note that experience in the development and introduction of gas pumping units was the basis for the creation of fundamentally new processing and power engineering installations for constructing and operating oil fields and for the processing and transportation of petroleum gas.

This involved the creation of aircraft engine based block-container type electric generators driven by gas turbines of varying power to supply oil

fields with electric power; gas turbine pumps, and block gas compressor installations to dehydrate gas by low temperature separation and to compress it for transportation to customers.

The creators of qualitatively new gas compression equipment also take into account another tendency -- further increases in gas pipeline capacity through the use of long distance high pressure multipipe pipelines. This is why the task of building gas compressor units with much larger aircraft engines (25,000 kW) has been posed.

In turn, as the power of the sector's compressor stations is sharply increasing, and it has become one of the largest users of natural gas, making it necessary to improve gas compressor units power engineering indicators both through the use of the steam gas cycle and through the introduction of various heat recovery schemes. For example, a truly economical approach to the matter was the introduction, at compressor stations with GPA-Ts-16 units, of heat recovery systems -- steam-gas units of up to 10 MW for generating electrical and thermal energy, in other words, the creation of power engineering-compressor stations.

Finally, the introduction of microprocessors, both for control purposes and for general improvements in equipment operation technical standards could become a most promising direction in the development of gas compression units is the development of gas compressor units.

Actually, the high levels of automation at units using aircraft engines and experience in the diagnosis of gas turbine engine conditions acquired at organizations in the Ministry of the Aviation Industry and the Ministry of Civil Aviation helped put on the day's agenda a truly revolutionary task: the creation of new types of machines, equipped with sets of automated systems for the technical diagnosis and prediction of conditions (ASTD). The building of ASTD as a component part of multilevel integrated systems for the automated management of gas transportation enterprises (ASU GTP) based upon small control computers and microprocessors assures the greatest improvements in reliability and efficiency. The advantages of control by such machines is obvious. There are also sharp increaes in unit capacity and efficiency factors, reductions in idle time, emergencies, repair time and spare parts inventories.

The first such ASU based upon microprocessors is being introduced at the experimental compressor station in Togliatti, where there is an aircraft engine power unit. Beginning in 1986 it is planned to put such systems into series production.

Also, it is exceptionally important that the high levels of automation, together with technical diagnosis makes it possible to, in the final account, convert to the servicing of equipment as condition demands it, without the constant presence of service personnel. It is just such compressor stations "turnkey" compressor stations which are needed in remote and inaccessible areas.

One can already see future completely automated compressor stations operating without a soul present. Similarly to large power engineering systems, such gas transport systems could be controlled from a centralized panel.

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There are broad prospects for the use of aircraft engine powered units. Work is now under way on the creation of many machines we have discussed. Several difficult scientific and engineering problems must be solved, however specialists can handle them. They are made confident by the successful mastery of the series production of the GPA-Ts-16. This unit and subsequent ones will become a specific contribution of scientists and engineers to increasing the extraction of oil and gas, which is considered not only very important economically, but also politically.

NEW SWIRL-TYPE IGNITION SYSTEMS FOR GAS TURBINE ENGINES AND OTHER POWER
APPARATUS

[Article by K.A. Shchennikov, engineer, V.G. Tyryshkin, doctor of technical
sciences, and I.S. Bodrov, engineer, Turbine Design Department, Leningrad
Metal Works Plant and Higher Technical Educational Institution]

[Abstract] Igniting the fuel-air mixture directly in the electrical spark
plug, as is currently done in combustion chambers of gas turbine engines,
has several drawbacks which include carbon and moisture deposits as well as
heavy thermal and mechanical loads as likely causes of malfunctioning or
even failure. A crucial factor determining the reliability of ignition is
maintenance of spark in the stabilization chamber; extensive studies have led
to development of a new ignition system which ensures this by producing a
spark which is hotter and more resistant to cutoff by the air stream. The
main obstacle to uniform combustion has been found to be formation of a
"barrier" by rich mixture. Its prevention, and formation of a steadily
propagating flame front is possible by adjustment of the rate of fuel
injection into a swirling constant-rate air stream so that the cross-section
of the flame "cord" in the burner tube will vary correspondingly, becoming
smaller when the mixture is too lean and larger when the mixture is too rich.
Air and fuel can be admitted through separate intake manifolds or mixed
before admission through a common intake manifold. The model F36 ignition
system of this kind includes a throttle and an air compressor. Two sets of
six with separate intakes, for the high-pressure chamber and the low-
pressure chamber respectively, were tested on a GT-100 gas turbine and found
to start it up within 4-25 s. Figures 3; tables 1; references: 2 Russian.

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LENGTHENING LIFE OF CYLINDERS IN INTERNAL COMBUSTION ENGINES

[Article by M.A. Gogolitsyn, candidate of technical sciences, and A.A. Kodin, engineer]

[Abstract] A comparative study of cylinders for internal combustion engines was made, cylinders having their active surface treated by conventional honing or by more efficient and economical burnishing for surface hardening and higher wear resistance. Cylinders for a D37Ye air-cooled diesel engine were selected for the experiment, these cylinders being made of a special cast iron (3.3-3.7% C, 1.7-2.3% Si, 0.6-1.2% Mn, 0.4-0.6% Cr, 0.1-0.3% Ni $\le$ 0.2% P, $\le$ 0.14% S). The burnishing process is described by a system of three regression equations with two independent variables (burnisher-cylinder interference, number of passes) and three dependent variables (eccentricity of cylinder hole, surface finish, and depth of the hardened surface). The life of a cylinder is essentially determined by the hardened surface depth, which was calculated for given eccentricity and surface finish by the method of indeterminate Lagrange multipliers: 0.36 mm, with 0.12-0.13 mm interference and 2 burnisher passes. The laboratory part of the study, for confirmation of the results, included friction and wear tests at rubbing velocity of 18 m/s under pressure of 0.07 Pa with M10G oil as lubricant. The results indicate a 30.6% smaller total wear after burnishing than after honing. To this advantage must be added a 2.4 times faster surface finishing operation, 1.34 times less time per piece, and a much lower tooling cost. References 2: 1 Russian, 1 Western.

GAS TURBINE COMBUSTION CHAMBER NOISE AND SOME POSSIBILITIES OF REDUCING IT

[Article by V.A. Khristich, professor and doctor of technical sciences, A.M. Shevchenko, candidate of technical sciences and I.M. Zherebtsov, engineer, Kiev Order of Lenin Polytechnical Institute imeni 50th Anniversary of the Great October Socialist Revolution, presented by Department of Environmental Protection and Thermal Power Systems]

[Abstract] Acoustic oscillations of the gas column are the basis for resonant noisy combustion modes in gas turbines and suppression of these oscillations reduces combustion chamber noise. An acoustic damper in the

form of a flame tube with perforating holes can provide maximum absorption
of the pressure oscillation energy in the combustion chamber. The significant
design parameters for such perforated flame tube suppressors are the per-
centage of the tube area covered by the perforating holes and the spacing
between the two walls of the resonant cavity. A flame tube with 2 mm
diameter holes taking out 4.2% of the tube area and a 15 mm spacing between
the chamber housing and the flame tube wall was shown to nearly completely
cut off the maximum noise pressure peaks. This configuration does not
suppress low amplitude noise oscillations at other frequencies off of
resonance and even results in the excitation of some additional frequencies.
because of the sharp frequency response of this damper design. A significant
improvement is a flame tube made with two walls, each of which is perforated.
This configuration both increases the service life of turbine combustion
chamber and effects an overall reduction in the generated noise. A graph
shows the temperature of the perforated flame tube walls as a function of
the perforation area and heat load. Figures 3; references 10: 5 Russian,
4 Western (1 in Russian translation).

THERMAL STATE OF STEAM SUPERHEATER WHEN TURBINE EXTERNALLY INFLUENCED BY
STEAM RATE OF FLOW

[Article by Ye.A. Blinov, candidate of technical sciences, Northwest
Correspondence Polytechnical Institute, presented by Department of Thermal
Power Engineering]

[Abstract] When a boiler unit is externally influenced by the steam rate of
flow through the superheater, the thermal status of the sections and super-
heater as a whole is determined by particular combinations of perturbations.
A combination of no more than two perturbations can act on the superheater
section: a step disturbance of the steam rate of flow and a timewise
changing saturated steam temperature can act on the heated section on the
saturated steam side; this combination can also act on the heated section
on the superheated steam side as a response of the previous superheater
section to this same external input. One timewise variable perturbation –
the steam temperature as a response of the previous section – may act on the
unheated section; the timewise changing steam temperature as a response of
the previous section and the step change from the relative injection are
perturbations acting in the spray section (for a spray attemperator).
Equations are written for each of these perturbation scenarios and then analyzed
in order to ascertain the resulting steam temperature changes at the outlet
of superheaters. The saturated steam temperature perturbation in a wall-type

radiant superheater of a TGM-84/B boiler when the steam rate of flow is
reduced and the fuel oil rate of flow into thefurnace is dropped from 100%
to 80% is shown graphically as a function of time. A similar graph is plotted
for the steam temperature change at the output of a convective superheater;
in no case do the transient phenomena last more than about 350 seconds.
Figures 3; references: 4 Russian.

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ON PROBLEM OF DESIGNING SETTINGS OF TURBINES WITH VARIABLE CIRCULATION STAGES

[Article by M.Ye. Levina, professor, doctor of technical sciences and
V.A. Shevchenko, candidate of technical sciences, Kharkov Order of Lenin
Polytechnical Institute imeni V.I. Lenin, presented by Department of Turbine
Building]

[Abstract] Failure to observe the condition of constant circulation with
respect to height in the design of a turbine stage results in additional
output velocity losses, since a peripheral component of the output velocity
appears that changes over the height. Designing the nozzle set of the
following stage with an entrance angle that varies over the height can
practically fully eliminate the potential losses, however, such nozzle
structures encounter difficulties related to the different configuration of
the root and peripheral shrouds, making it difficult to fit the blading
in during the assembling of the nozzle set. This paper ascertains the range
of geometric parameters of a variable circulation stage for which the use of
nozzle sets with an axial inlet over the entire height in the following
stage creates no marked drop in the efficiency. The proposed procedure
allows the simple evaluation of the necessity of special shaping of the
nozzle sets of the following stages in turbines, and in a typical case for
a high pressure turbine adduced as an example, the efficiency loss with a
standard axial entrance was less than 1.2%. Figures 3; references:
4 Russian.

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RESULTS OF TESTS PERFORMED ON TURBOFAN TURBINE LUBRICATION AND REGULATION
SYSTEM IN 800 MW POWER UNIT DURING INTERRUPTION OF POWER SUPPLY TO STATION
AUXILIARIES

[Article by V.Kh. Georgiadi, engineer, A.V. Malyshev, engineer,
N.V. Kholshcheva, engineer, V.L. Karapazyuk, engineer, and A.V. Andreyeva,
engineer, All-Union Administration of Power System Equipment and Ryazan GRES]

[Abstract] The turbofan turbine lubrication and regulation system in an
800 MW power unit was tested during interruption of power supply to station
auxiliaries. In that 800 MW power unit an OK-18PV condensing steam turbine
with independent bearing lubrication system supplied from a 10 m^3 oil tank
drives the VDN-36x2 air blowers for the TGMP-204P gas-heated or oil-
heated boiler. The two a.c. motors driving the main oil pump and the
reserve oil pump are energized from different sections of the 400 V distri-
bution panel. The d.c. motor driving the emergency oil pump is energized
from busbars on the d.c. panel. The purpose of testing was to determine
whether connecting the d.c. motor of the emergency oil pump alone, in
accordance with given pressure and time settings, will ensure continued
operation of the turbofan when both a.c. motors are disconnected. Four
tests were performed with the turbofan not operating: 1) automatic
starting of the reserve oil pump a.c. motor upon disconnection of the main
oil pump a.c. motor; 2) automatic starting of the emergency oil pump d.c. motor
upon disconnection of the main oil pump a.c. motor; 3) automatic starting of
the reserve oil pump a.c. motor upon dropping of the oil pressure after
disconnection of the main oil pump a.c. motor; 4) disconnection of the main
oil pump a.c. motor when automatic starting of both the reserve oil pump a.c.
motor and the emergency oil pump d.c. motor has been prevented. In addition,
tests 2) and 3) were performed with the turbofan running at 400 rpm. The
results of these tests reveal that the transient characteristics of the
turbine lubrication and regulation system are not the same when the turbofan
runs and when it stands still. They indicate that operation of the turbofan
will not be destabilized by a 5 s long interruption of the a.c. power
supply. Energizing the reserve oil pump a.c. motor from a section of the
400 V distribution panel in a neighboring power unit will increase the
reliability of turbofan operation. The number of starts of the emergency
oil pump d.c. motor can be reduced by lengthening the set time delay to 3-4 s
after disconnection of the main oil pump a.c. motor and failure of the
reserve oil pump a.c. motor to start. Figures 2.

CAUSES BEHIND INCREASED VIBRATION OF BEARINGS IN TURBOGENERATORS WITH FORCED
COOLING OF ROTOR WINDINGS

[Article by A.T. Lebedev, engineer, S.G. Khaymin, engineer, S.E. Saar,
engineer, and L.P. Khalyavin, engineer, Ural Regional Administration of
Power System Equipment and Kirov Regional Administration of Power System
Business]

[Abstract] The vibration of bearings in TVF turbogenerators has noticeably
increased in recent years, evidently owing to a heat unbalance in the rotor
created by partial blockage of cooling ducts. The generator bearings of the
TVF-60-2 turbogenerator No 6 in the Kirov TETs-4 were found to vibrate more
intensely at a rotor current of 1700 A and higher, the amplitude of their
vibration reaching already 115 μm at nominal rotor current so that the
latter had to be lowered to 1400 A. In search of the causes and a remedy,
heat and vibration measurements were made at three power levels (30-40-50 MW)
with the rotor coolant maintained at nominal temperature and pressure while
the rotor current was varied over the 1200-1700 A range. Axial and transverse
vibration in the horizontal plane as well as vertical vibration were measured
with standard gauges and also with a BIP-6M inspection gauge. The results
reveal that the vibration amplitudes do not depend on the generator power as
long as the rotor current does not exceed 1300 A. The amplitude of axial
vibration reached 50-60 μm as the rotor current reached 1500 A and became
115 μm at a rotor current of 1600 A. The temperature rises in the stator
winding-and core were normal, 64°C and 59°C respectively, while a heat un-
balance in the mechanically balanced rotor was found to develop as the
temperature in the rotor winding reached 71°C. This has been attributed
to constriction of the cooling ducts which pass air directly through the
rotor winding. The only possible remedy was rewedging the rotor coils in the
slots. Such a redesign, based on analysis of the air flow vector diagram,
has resulted in a symmetric air velocity and temperature rise pattern with an
attendant decrease of the axial vibration amplitude to 30 μm and of the rotor
winding temperature rise by 15°C. Application of the same principle of the
TVF-60-2 turbogenerator No 2 reduced the amplitude of vertical vibration
of the generator bearings from 140 μm to 60 μm and the temperature rise in
the rotor winding from 136°C to 126°C, still not sufficiently because of
the only partial rewedging of coils: in only two and not in all six slots.
Figures 4.

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DEVELOPMENT AND EVALUATION OF HIGH-EFFICIENCY TURBINE STAGES WITH MINIMUM
PERIPHERAL LEAKAGE

[Article by M.Ye. Levina, doctor of technical sciences, B.I. Frolov,
candidate of technical sciences, and V.A. Shevchenko, candidate of technical
sciences, Kharkov Polytechnic Institute]

[Abstract] Design of a turbine stage is considered where peripheral leakage
into clearances above the runner has been minimized not by use of better new
seals but by elimination of its cause. Accordingly, the stage is designed
with a near zero reactivity index at the blade tips over the entire runner
height. This requires curving the meridional streamlines and thus a special
configuration of nozzles. The radial reactivity gradient must be minimized
at the same time, and controlled so as to ensure not more than 1% suction at
the blade roots and thus no leakage through the diaphragms. This is achieved
by backward twisting or tangential slanting of the nozzle blades, or by a
combination of both. Efficiency and economy of such a stage can be restored
by utilization of the exit velocity in the next stage, the latter having the
entry angle vary appropriately over the runner height. Such a design
concept was evaluated on three prototype turbine stages and found to be ex-
pedient only in the case of wide clearances, wider than an empirically
established break-even size, so that the decrease of losses due to peripheral
leakage will compensate the increase of other losses. A high-efficiency
stage with near zero peripheral reactivity is feasible regardless of clearance
width when the diameter-to-length ratio exceeds 8, a stage with $D_m/L = 19$
having been found to be very efficient, which is the range for high-pressure
cylinders of 100-150 MW turbines. Figures 5; tables 1; references:
6 Russian.

FLUID MECHANICS

FLOW STRUCTURE BEHIND BODY EXPOSED TO HYPERSONIC FLOW WITH INTENSE RADIATIVE
HEAT EXCHANGE

[Article by S.P. Popov, Computer Center of the USSR Academy of Sciences]

[Abstract] A heat conducting, nonviscous gas flows at hypersonic velocity
(more than about 50 km/s) around a two-dimensional body. The parameters of
motion of the steady-state flow are chosen so that the radiative heat ex-
change, described in an approximation of radiative heat conductivity, is the
dominant process for energy distribution near the body. A system of four
partial differential equations is solved numerically in order to determine
the flow geometry and parameters at distances of 50 to 80 times the body
diameter downstream. The shock wave intensity falls off rapidly with
increasing distance from the body and the gas has a nearly constant density
and temperature at a distance of 10 diameters. The density in the disturbed
region changes little out to 40 diameters, while the velocity increases and
the gas cools. The flow is characterized by a gradual change in the relation-
ship between the energy of gas motion radially and the energy redistributed
by radiative heat conductivity in such a way as to decrease the share of the
latter, which decreases rapidly with the drop in the gas temperature. The
generation of the shock wave in the interior of the thermal region surround-
ing the body occurs at distances of 30 diameters. Such flows can be
modelled at distances beyond 50 diameters from the body by a simple sub-
stitution of an effective point heat source, thus greatly simplifying the
computations. Figures 3; references 4: 3 Russian, 1 Western.

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INTERNAL SHOCKWAVES DURING SUPERSONIC FLOW OF IDEAL GAS ABOUT WEDGE-PLATE AND
CONE-CYLINDER CONFIGURATIONS

[Article by V.L. Grigorenko and A.N. Krayko]

[Abstract] The characteristics and factors underlying internal shockwaves
that occur when a nonviscous, non-heat conducting gas flows about wedge-
plate and cone-cylinder configurations is investigated. Shockwaves are
found to occur for the entire range of Mach numbers investigated for the
cone-cylinder configuration; however, flows with overexpansion (in which the
pressure beyond the discontinuity is lower than the pressure of the oncoming
stream) as well as underexpansion are possible for the wedge-plate configuration,
so that a supersonic flow without shockwaves is possible. The effect of the
temperature and viscosity of the gas on shockwave formation is investigated.
It is found that supersonic flows that do not contain shockwaves are more
the exception than the rule in semibounded regions, which is natural for
solving quasilinear hyperbolic-type equations. Figures 4; references 20:
17 Russian, 3 Western.

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MULTI-DIMENSIONAL SELF-SIMILAR PLANE WAVE SOLUTIONS IN GAS DYNAMICS

[Article by S.A. Poslavskiy and I.S. Shikin]

[Abstract] Adiabatic movements of an ideal gas with plane waves are
investigated. Self-similar solutions are derived for uniform expansion of
the gas in the planes perpendicular to the main direction of movement. The
self-similar problem of a brief shock is investigated for uniformly expanding
gas. Plots are presented of the distribution density, pressure, and velocity.
Figures 4; references 6: 4 Russian, 2 Western.

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EFFECTS OF LOCALIZATION AND STRUCTURE FORMATION DURING COMPRESSION OF FINITE
MASS OF GAS IN PEAKING MODE

[Article by M.A. Lemidov and A.P. Mikhaylov]

[Abstract] Adiabatic compression of a finite mass of gas by a flat,
cylindrical, or spherical piston is investigated. 'Localization of gas
dynamic processes is observed when the index of symmetry is zero, in which
perturbations penetrate no further than some finite mass of the gas regard-
less of the pressure on the piston. The formation of gas dynamic structures
is observed, including complex ones consisting of localized temperature or
density maxima that are associated with a fixed gas mass. Localization
indicates that it is theoretically possible to concentrate and confine any
amount of energy for a finite amount of time in some mass of matter without
affecting the rest of the mass. The formation of structures provides addi-
tional ways to control the compression process by creating nonmonotonic
temperature and density distributions in the compressed substance.
Figures 5; references: 16 Russian.

VIBRATIONAL-CONVECTIVE INSTABILITY OF HORIZONTAL FLUID LAYER WITH INTERNAL
HEAT SOURCES

[Article by G.Z. Gershuni, Ye.M. Zhukhovitskiy, and A.K. Kolesnikov, Perm]

[Abstract] Vibrations and convection in an infinitely large horizontal
fluid layer between two parallel solid plates are analyzed for instability
buildup when such a layer contains internal heat sources uniformly distributed
over its volume. The layer generally lies in a gravitational field and
vibrates at a high frequency in a fixed direction $\vec{n}$ at some angle to one of
horizontal axes of the layer. The boundary constraints on the corresponding
field equations for the average velocity $\vec{v}$, temperature T, convective pressure
p, and the solenoidal component $\vec{w}$ of the $T\vec{n} = \vec{w} + \nabla\phi$ vector field are adhesion
of the fluid to the solid surfaces, zero normal component of $\vec{w}$, and closure of
the fluctuation component, the temperature being either the same and constant
at both upper and lower boundaries or remaining constant at the upper
boundary with the lower boundary thermally insulated. From this system are

derived the conditions for mechanical equilibrium and convective stability. Convective instability is then analyzed by the method of small perturbations and by solution of the corresponding spectral problem. The solution to this problem obtained by the Runge-Kutta-Merson method of numerical integration reveals the mode of instability buildup in the two extreme but simplest cases of a static gravitational field without vibrations and weightlessness with vibrations. The instability buildup can be monotonic or oscillatory, depending on the temperature field with the two boundaries at equal or different constant temperatures, or with one at a constant temperature and the other thermally insulated, and in the case of vibrations on the inclination angle of the vibration axis. The calculations yield also the instability threshold depending on the magnitude of the convective or vibrational critical Rayleigh number. Figures 3; tables 2; references 4: 2 Russian, 2 Western.

BUILDUP OF TWO-DIMENSIONAL AND THREE-DIMENSIONAL FINITE-AMPLITUDE PERTURBATIONS IN JETS

[Article by S.Ya. Gertsenshteyn, I.I. Olaru, A.Ya. Rudnitskiy, and A.N. Sukhorukov, Moscow]

[Abstract] Transition from laminar to turbulent jet flow is analyzed as a problem of stability, in the approximation of a nonviscous fluid. The corresponding initial-and-boundary-value problem for the three-dimensional Euler equations of flow kinetics is solved according to the Bubnov-Galerkin procedure and with the aid of the Squire transformation, after the velocity profile of the main flow has been piecewise-approximated so that an analytical solution in Rayleigh series can be obtained for each segment. The problem is thus reduced to a system of ordinary differential equations for the series coefficients, solvable by the Kutta-Merson method of numerical integration with automatic selection of the integration interval and monitoring of the accuracy. Calculations have been made on a BESM-6 high-speed computer for six different combinations of velocity profile and perturbation parameters and altogether 48 different combinations of parameter values. The results have been analyzed for linear stability corresponding to finite or asymptotic buildup of fluctuation amplitude, also in the limiting case of a smooth velocity profile, and for nonlinear interaction of perturbations particularly in the two extreme cases of the product of wave number and displacement boundary layer thickness approaching zero or larger than unity. The analysis reveals a dominance of long-wave components and mutual suppression of medium-wave components. Symmetric fluctuations are found to grow to an amplitude one order of magnitude smaller than that of antisymmetric

fluctuations and to become dominant in an acoustic field. The analysis reveals also a secondary instability, namely that of two-dimensional finite-amplitude fluctuation modes under transverse three-dimensional perturbations. Figures 5; tables 6; references 12: 7 Russian, 5 Western (1 in Russian translation).

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SPECTRUM OF ACOUSTIC EMISSION FROM BOUNDARY LAYER ON ROUGH SURFACE

[Article by V.P. Reutov, and G.V. Rybushkina, Gorkiy]

[Abstract] A turbulent boundary layer moving at subsonic velocity on a rough rigid surface is considered, and the spectrum of acoustic emission from it is estimated on the basis of a correlation analysis. The turbulence is assumed to be stationary and statistically uniform with respect to both space coordinates in a plane of the layer. The power spectrum of acoustic pressure is obtained with the aid of the Parseval theorem and the two correlation functions for gradients of the surface level are calculated for a simple model of a sand surface. The frequency range and the intensity of dipole emission are in this case found to be respectively higher and much higher than those of quadrupole emission. The scattering effect is strongest in the intermediate range corresponding to $k_T b \sim 1$ ($k_T = \omega/v_c$, ω- frequency of fluctuations, v_c- velocity of convective drift, b- characteristic dimension of surface roughness: width of asperity and, in the case of close packing, also its equivalent height) so that the "dip" in the emission spectrum caused by a low spectral intensity of pseudosound occurs only when the surface roughness is very fine and scattering is therefore principally the high-frequency component is scattered. Figures 2; references 10: 7 Russian, 3 Western.

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BIFURCATION OF DEVELOPED FLOW THROUGH RECTANGULAR CHANNELS ROTATING ABOUT
TRANSVERSE AXIS

[Article by Ye.M. Smirnov, Leningrad]

[Abstract] Steady-state flow of a viscous incompressible fluid through a
long rectangular horizontal channel rotating at a constant angular velocity
about its vertical axis is analyzed, assuming constant profiles of all
velocity components in all normal sections. The corresponding nonlinear
Navier-Stokes equations are formulated in a Cartesian system of coordinates
rigidly and symmetrically fixed to the channel, and are solved by the emplace-
ment method according to an implicit finite-difference scheme for boundary
constraints of adhesion and with a fictitious compressibility term inserted
into the equation of continuity. The results reveal a bifurcation of flow
with formation of a secondary Eckman shear flow at the horizontal walls and
with the primary flow evolving into successively one to three pairs of Taylor
vortices at the bearing wall within a certain range of the Reynolds number and
of the ratio of tangential velocity due to channel rotation to longitudinal
velocity outward, both being eventually combined into the Dean number as
criterial argument of the hydraulic drag. The stability limit of the
Poiseuille primary flow has been estimated asymptotically and found to be
raised by sufficiently fast rotation of the channel. Figures 5;
references 14: 6 Russian, 1 Polish, 7 Western.

FLOW OF VISCOUS FLUID UNDER ROTATING DISK INSIDE CYLINDRICAL VESSEL

[Article by V.S. Berdnikov, V.I. Polezhayev, and A.I. Prostomolotov, Moscow]

[Abstract] Flow of an isothermal viscous fluid under a floating and rotating
disk inside a cylindrical vessel is analyzed, this being a model problem of
crystal growing by the Czochralski method. The disk covers the free surface
of the fluid completely, forming in effect a lid, or only partially as in
a Czochralski crucible. The theoretical analysis is based on the
corresponding system of Navier-Stokes equations of nonsteady flow with
axial symmetry, in either natural variables (three principal velocity com-
ponents, pressure) or artificial variables (vortex, flow function), and its

numerical solution by the method of finite elements or the method of finite differences respectively. Experimental data were obtained with cylindrical quartz crucible containing 96% ethyl alcohol and copper disks of various diameters on a vertical shaft through the bottom. The crucible was placed inside a housing made of acrylic glass and square in cross section, with sufficient clearance for water. The disk was driven at speed of 1-300 rpm, any speed being maintained constant within $\pm 1\%$. For visualization of the flow and photographic study by the schlieren method, a monodisperse fraction of 10 μm thick aluminum flakes was suspended in the alcohol. Measurements were made with the Reynolds number varied up to $N_R = 2 \cdot 10^4$ and the ratio of fluid height H to cylinder radius R_C varied over the $0.2 \leq H/R_C \leq 1.4$ range, using one disk with a radius equal to the cylinder radius R_C and one disk with a radius equal to $0.36 R_C$. An analysis of the main flow, on steady flow with secondary vortices, and on oscillatory flow reveals how the characteristics and the stability range of each mode depend on those three test parameters. Figures 5; references 14: 8 Russian, 6 Western.

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INITIAL FLOW SEGMENT IN SQUARE CHANNEL ROTATING ABOUT ITS TRANSVERSE AXIS

[Article by O.N. Ovchinnikov and A.V. Rukolayne, Leningrad]

[Abstract] Flow of a viscous incompressible fluid in a semi-infinitely long channel with square cross-section is analyzed, of particular interest being development of laminar flow. The corresponding system of Navier-Stokes and continuity equations, partial differential equations of the elliptic kind, is simplified so as to become analytically or numerically solvable as the Reynolds number increases. For this purpose, the three-dimensional Laplace operator is replaced with the two-dimensional one and the longitudinal apparent-pressure gradient is replaced with its mean over the cross-section. The system of equations is thus reduced to a parabolic one with respect to the longitudinal coordinate and, as such, can be split and then solved for the given boundary conditions through numerical integration by the cruising method. The boundary conditions for the flow function and the vorticity are extensions of the Thom conditions to the quasi-three-dimensional case. After conversion to discrete form, this system of equations is solved in three stages. First the pressure gradient and the axial velocity field are calculated. Then the Neumann problem for the Poisson equation is solved for the flow function. Finally the velocity field of secondary flow is calculated. Results have been obtained for the $0 \leq 1/N_{Ro} \leq 1.5$ range of the Rossby number and the $0 \leq N_{Re} \leq 250$ range of the Reynolds number, actually the

$0 \le z/N_{Re} \le 0.1$ range (z- dimensionless longitudinal coordinate).
Figures 5; references 16: 8 Russian, 8 Western (2 in Russian translation).

THERMOCAPILLARY MECHANISM OF CONVECTION IN FLUIDS FOLLOWING ABSORPTION OF LASER RADIATION PERIODICALLY DISTRIBUTED IN SPACE

[Article by R.S. Akopyan and B.Ya. Zeldovich, Moscow]

[Abstract] Absorption of light by a plane layer of a viscous fluid such as dye solution in an isotropic solvent and subsequent thermocapillary convection in such a layer are analyzed, assuming a constant temperature and a zero vertical velocity at the rigid bottom surface z = 0. The light impinges in a periodic interference pattern produced by two waves of the same length with linear polarization. For simplification, the horizontal x,y axes of coordinates in the plane of the layer are rotated so as to reduce the y-component of the difference of wave vectors to zero. At the free surface z = L the boundary conditions for the viscous stress tensor are stipulated by taking into account the thermocapillary force as well as surface tension, and the boundary conditions for heat transfer are stipulated assuming a thermal flux proportional to the temperature rise, with a zero vertical z-component of velocity. For an evaluation of the thermocapillary convection, convective volume forces are disregarded and the fluid layer accordingly assumed to be sufficiently thin. The corresponding system of field equations is solved for both velocity and temperature distributions after impingement of light with attendant departure from a prior equilibrium state. The depthwise temperature profile is found to be parabolic and numerical data indicate a very strong thermocapillary effect, with a convection velocity v_z of the order of 0.1 cm/s in a layer approximately 0.1 cm thick at a power density of incident interfering light waves as low as 1 W/cm^2. The authors thank N.T. Pashchenko, N.V. Tabiryan, and Yu.S. Chilingaryan for valuable discussions. Figures 1; references 5: 4 Russian, 1 Western.

ROTATIONAL MOTION RESULTING FROM HYDRODYNAMIC INSTABILITY

[Article by M.A. Goldshtik, Ye.M. Zhdanova, and V.N. Shtern, Novosibirsk]

[Abstract] Axisymmetric jet flow of a viscous incompressible fluid is analyzed, assuming that the jet is submerged and that the flow is initially parallel with a velocity field $v = (0,0,V(r))$ in a cylindrical system of coordinates, r,ϕ,z so as to represent an approximate solution to the corresponding Navier-Stokes equations. Departure from this ideal condition of parallel flow and the periodic modes of secondary flow evolving as a result are evaluated by introduction of a velocity increment in cylindrical coordinates moving in the direction of flow and subsequent solution of the corresponding nonlinear eigenvalue problem. This is done by the Lyapunov-Schmidt method, assuming a finite parallel initial flow. The transients and the evolving secondary modes are then calculated in accordance with the theory of perturbations, with the equations for the amplitudes solved by the method of differential forward and reverse sweeping and subsequent numerical integration by the standard Runge-Kutta method with automatic selection of the integration interval ensuring the necessary precision. The results reveal a branching of secondary jets with a loss of symmetry, and spontaneous rotation of the nonaxisymmetric modes $m = \pm 1$ following their loss of stability. This anomalous behavior has been confirmed by an analytical solution of those equations in modified Bessel functions. Figures 4; references 20: 5 Russian, 15 Western.

DYNAMICS OF SPRINKLER JETS

[Article by M.T. Murzabayev and A.L. Yarin, Moscow]

[Abstract] The dynamics of water sprinkler jets emanating from nozzles at some elevation angle and the ballistics of droplets after breakup of such a jet are analyzed, assuming that the breakup occurs much faster than the subsequent passage of droplets through the water-air cloud. The corresponding system of four equations describing the average flow of an axisymmetric turbulent two-phase jet consists of an equation of continuity and an equation of momentum for each phase. It is solved for the simple case of a jet

trajectory following a plane curve, which corresponds to absence of a lateral
wind. The eddy viscosity is described by semiempirical relations known to hold
true for gas jets carrying solid particles. Theinitial conditions, referring
to breakup of the jet, are established by backward extrapolation from con-
servation of momentum along the jet trajectory and conservation of water mass.
The boundary conditions are zero radial velocity gradient at the jet axis and
zero velocity at infinity. Numerical calculations have been made for two
jets, one leaving a nozzle 0.025 m in diameter with an initial velocity of
33 m/s at an elevation angle of 28° and one leaving a nozzle 0.012 m in
diameter with an initial velocity of 26.2 m/s at an elevation angle of 28°.
The hydraulic resistance coefficient for water was assumed to be 0.43 in
each case. The results agree closely with available experimental data, which
suggests that this theory and method of analysis can be extended to water
sprinkler jets in a lateral wind. Figures 5; references 18: 13 Russian,
5 Western (1 in Russian translation).

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INTERACTION OF PERTURBATIONS IN BOUNDARY LAYER

[Article by V.V. Babenko and N.F. Yurchenko, Kiev]

[Abstract] An experimental study of three-dimensional perturbations in a
boundary layer on an elastic surface was made, for the purpose of determining
the physical pattern of their interaction. The flow field was visualized by
the tellurium method, both the average part V and the fluctuation part v'
of the longitudinal velocity as well as the spectral power density E(k)
of the latter (k- wave number were measured with a laser-Doppler velometer
and a DISA 55D01 thermoanemometer set. Perturbations were induced first by
the conventional method of inserting an array of turbulizers upstream relative
to the measuring instruments but "above" the solid surface underneath the
boundary layer and then also by perturbing the elastic plate from "below".
The readings were normalized so as to make

$$\int_0^\infty \frac{E(k)}{\langle v'^2 \rangle} \, dk = 1.$$ The results

differ from earlier results obtained with a rigid surface underneath the
boundary layer and perturbations induced from "above". The fluctuation
spectrum in the case of an elastic surface has dips particularly noticeable
in the range of large wave numbers, sharp peaks in the low-frequency range,
sharp spikes at certain wave numbers, and a degree of "smoothness" which
depends on the kinematic characteristics of the boundary layer as they change
during transition. Development of the turbulent flow appears to occur, however,

by the same mechanism as that of a viscous turbulent sublayer on a rigid surface. Figures 3; references 12: 10 Russian, 2 Western.

STRUCTURE OF SUPERSONIC TURBULENT BOUNDARY LAYER INTERACTING WITH COMPRESSION SHOCK

[Article by M.A. Goldfeld, Novosibirsk]

[Abstract] An experimental study of a supersonic turbulent boundary layer and its interaction with a compression shock was made at the Institute of Theoretical and Applied Mechanics (Siberian Department, USSR Academy of Sciences). Tests were performed in the T-313 wind tunnel, its straight segment 400 cm long and 60 cm in diameter being followed by a diffuser. The diffuser opening angle 2θ was varied from 20° to 50°. The air velocity in the straight segment corresponded to a Mach number $N_M = 3$ for the main test and $N_M = 2, 2.5, 4$ for control tests. The boundary layer in the diffuser segment was at least 5 mm thick and the Reynolds number in it was varied over the $(3-12)\cdot 10^3$ range, referring to its momentum-loss thickness as characteristic dimension. Measurements have yielded data on the pressure distribution and the velocity profiles behind a compression shock with ($2\theta = 500$) and without boundary layer separation, and also on the skin friction coefficient. These data indicate a departure from power-law velocity profiles in the boundary layer and rather an approach to Schlichting-van Driest "wall-wake" profiles describable as a superposition of constant (Prandtl), linear (Cowles), and a logarithmic profiles. Figures 6; references 13: 9 Russian, 4 Western (1 in Russian translation).

DETERMINATION OF SHAPE OF NARROW AXISYMMETRIC CAVITY FLOW ON BASIS OF
INTEGRO-DIFFERENTIAL EQUATION

[Article by I.G. Nesteruk, Nikopol]

[Abstract] A narrow axisymmetric cavity flow is described by an integro-
differential equation for its radius as a function of the axial coordinate
and time. This equation includes a small parameter ε, the ratio of
characteristic transverse dimension to characteristic longitudinal dimen-
sion of the "cavitator-cavity-closure" system. For determining the shape
of such a transient cavity, this equation is reduced by asymptotic expansion
to a recurrence chain of linear first-order partial differential equations
in ε^2 and in $\varepsilon^2 \log \varepsilon$. For convenience, the origin of cylindrical coordinates
is moved from the center of the cavity to the surface of the quiescent fluid
at one end so that it becomes fixed for absolute values of the axial
coordinate and time in the direction opposite to the direction of motion
of the cavitator. The shape is then determined in the second-order
approximation on the basis of the first-order approximation, already
known for a conical cavitator. The calculations involve essentially
evaluating the Green's function for each successive value of the absolute
axial coordinate and subsequently evaluating the double time integral of
this function. Figures 1; references 20: 17 Russian, 3 Western (1 in
Russian translation).

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CSO: 1861/198

BOUNDARY LAYER ON BLUNT BODY IN STREAM OF GAS AND DUST

[Article by A.N. Osiptsov, Moscow]

[Abstract] The boundary layer of a flat or axisymmetric blunt body in a
steady gas stream carrying dust and flowing past the body with a large
Reynolds number is analyzed, on the basis of Klachko's relations for
mechanical and thermal interphase interactions in Nigmatulin approximation
and on the basis of Marble's model of identical spherical dust particles
with negligible volume concentration outside the boundary layer. The
dimensionless corresponding equations of motion and heat transfer, with the
temperature of the body given, with boundary conditions of zero velocity and

temperature at the surface, with bouncing of particles disregarded, and with the Prandtl number assumed to be $N_{Pr} = 2/3$, yield equations of a boundary layer beside a nonviscous outer region according to the theory of singular perturbation. Considering absence of inertial dust precipitation into the boundary layer, this system of equations is solved in the vicinity of the stagnation point. Numerical calculations have been made for the extreme case of negligible mass concentration of dust and with the parameter $\beta > \beta_c$, where β_c is the critical value below which inertial precipitation of dust becomes significant. Here it was assumed that $\beta_c = 4$, although β_c really depends on the Reynolds number and the body geometry. The author thanks V.P. Stulov for discussion. Figures 2; tables 2; references 15: 12 Russian, 3 Western.

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THEORY OF CIRCULATION FLOW IN BUBBLING BED

[Article by V.L. Zelenko and V.P. Misnikov, Moscow]

[Abstract] A viscous fluid filling a vertical cylindrical column with generally arbitrary cross-section is considered, gas bubbles being injected into it uniformly through its bottom section. The corresponding equations of motion for both phases are formulated, assuming a small volume of gas and disregarding its mass but including the Magnus-Zhukovskiy force on the apparent mass and considering either a Stokes motion (K = 9/2) or an Adamar-Rybchinskiy motion (K = 3) of the bubbles. This system of first-order partial differential equations for the gas concentration is first simplified by assuming a Froude number smaller than unity so that the N_{Fr}^2-terms become negligible and then supplemented with the equations of continuity for both phases, both liquid and gas assumed to be incompressible. Solving the problem of flow in such a bubbling bed involves determining the conditions for existence of and then the shape of a contact surface which separates regions containing no gas from regions containing gas only. The problem is solved here for an infinitely high circular cylinder with uniform injection of gas at an infinitely far cross-section. Steady-state solutions are sought in the class of straight-parallel flow modes, corresponding to a cylindrical separating surface. Such a solution is found to exist only in the range of the Archimedes number above critical and in this case to yield two finite-amplitude modes merging at that limit. Each mode is characterized by circulation with the liquid descending faster than a single gas bubble ascends. After consideration of a bubbling bed with free boundaries, the edge effects are evaluated on the basis of the two-dimensional problem in any vertical plane through the cylinder axis. Figures 4; references 12: 10 Russian, 2 Western.

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STRUCTURE OF DISCONTINUITIES DURING REAGENT-INDUCED CHANGE OF PHASE
EQUILIBRIUM IN PETROLEUM DISPLACEMENT PROBLEMS

[Article by A.F. Zazovskiy, Moscow]

[Abstract] The process of petroleum displacement by concentrates or by
additives which alter the phase equilibrium is analyzed on the basis of a
mathematical model which extends the one for crude oil with an active
impurity to a 3-component 2-phase system. The three components are the
extractant (crude oil or heavy hydrocarbons), neutral or basic displacer
(water or gas), and active substance (CO_2 or solvent for displacement by
gas nnder high pressure, surfactant for displacement by micellar solution).
The system is assumed to exist either in a single-phase state or in a 2-
phase state, with any component theoretically able to appear in each phase
in the latter case. The system of equations describing the flow of such a
multicomponent mixture through a porous structure is formulated so as to
include capillary and diffusion mechanisms, assuming that all components
are incompressible and disregarding the effect of pressure changes on the
phase equilibrium. This system of equations is closed by the constraints
of phase equilibrium in accordance with the corresponding triangular
(i.e. 3-component) phase diagram. The external solution, corresponding to
the large-scale approximation, represents three possible displacement
modes and they are graphically described by continuous paths on triangular
phase diagrams: 1) piston-like displacement of crude oil; 2) piston-like
displacement of a two-phase mixture; 3) displacement of crude oil alone or
also of second component with formation of a mixing zone. The internal
solution describes the structure of each kind of concentration discontinuity,
there are being generally two possible variants of each, and yields the
conditions for their stability. Figures 4; references 16: 15 Russian,
1 Western.

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SELF-ADJOINT SOLUTIONS DESCRIBING PROPAGATION OF SOLITARY WAVES ABOVE
SEABED CRESTS AND VALLEYS

[Article by I.B. Bakholdin, Moscow]

[Abstract] Propagation of solitary waves above an uneven seabed is described
by a system of two equations, a linear one of energy conservation and a
hyperbolic one of kinematics, this model being valid only when the wavelength
is much smaller than the radius of wavefront curvature and than the spatial
period of the seabed roughness. A horizontal seabed with a single surface
perturbation in the form of a straight semi-infinitely wide sloping crest or
valley is considered with a wave propagating parallel to the even seabed
surface. The wave velocity, V, generally a function of the energy density E
at the wavefront and of the altitude h above the seabed surface, becomes

$$V(E,h) = \sqrt{h}(1 + \frac{3}{8} \frac{E^{2/3}}{h^2})$$ for solitons with small relative amplitude. Self-
adjoint solutions are sought, and found to obey similarity laws. There
are six types of such solutions for a crest and seven types of such solutions
for a valley, including a steady-state solution in each case and solutions
for two supersonic ranges and for one subsonic range, if it exists, with
triple-soliton configurations at the two break points on the wavefront
impinging on the edge of a crest or a valley. Depending on the slope of
a crest or a valley, on the height or depth respectively relative to the
wavelength, and on the wave velocity, the amplitude of the wave remains
the same or is magnified or is attenuated so that the wave either will or
will not overcome the surface perturbation. The author thanks
A.G. Kulikovskiy and A.A. Barmin for attentiveness and valuable comments.
Figures 5; references 6: 3 Russian, 3 Western.

ULTRALOW TEMPERATURES ATTAINABLE DURING EXPANSION OF COMPRESSED GAS CLUSTERS

[Article by L.V. Shurshalov, Moscow]

[Abstract] Expansion of a spherical cluster of a compressed ideal nonviscous and thermally nonconducting gas into a gaseous ambient medium with a different adiabatic index is considered. The attendant flow is described as a transient process by a system of three homogeneous integro-differential equations of gas dynamics. The problem is to determine the radial velocity and temperature profiles as functions of time for $P_0/G_0 \geq 1$ (P_0 is the ratio of cluster pressure to ambient, G_0 is the ratio of densities), which corresponds to an initial cluster temperature not lower than the ambient temperature, and to determine the lowest temperature attainable within the region of the main shock wave under these conditions. Calculations made for $P_0/G_0 = 10$ with $P_0 = 10^4$ and $G_0 = 10^3$ indicate that the lowest temperature first drops fast along the wave coordinate, then jumps up as the secondary shock wave reaches the center of the region, then peaks slightly and levels off after reflection of the secondary shock wave. Typical estimates based on $T_\infty = 288$ K ambient temperature and $T_0 - 2880$ K initial cluster temperature yield in this case a lowest temperature of 19 K before the jump. These estimates are rough, inasmuch as phase transitions and attendant changes in the temperature dependence of thermophysical properties have been disregarded in the equation of state and its solution. The size of the low-temperature region and the mass of gas it contains are also estimated on this basis. The cooling effect weakens and the low-temperature region shrinks as the initial cluster temperature is raised and thus the ratio P_0/G_0 is increased, the low-temperature region having vanished completely when P_0/G_0 is of the order of 100, while the cooling effect becomes stronger and a larger mass of gas is cooled when the initial cluster temperature is lower with the ratio P_0/G_0 decreased to the order of 1. Figures 5; references 8: 6 Russian, 2 Western (1 in Russian translation).

SUPERCRITICAL NONLINEAR INTERACTION OF SUBSONIC JET AND SUPERSONIC JET FORMING STREAM OF NONVISCOUS GAS IN PLANE CHANNEL

[Article by D.O. Lyzhin, T.V. Titovskaya and V.N. Trigub, Moscow]

[Abstract] Flow of a nonviscous gas through a plane horizontal channel is considered in the form of a supersonic ($M_2>1$) jet as main part of the stream and a thin subsonic ($M_2<1$) jet along the lower wall. The steady-state problem of small perturbations of the initial pressure is formulated so that the ripple of the subsonic jet along the channel will have an amplitude comparable with its quiescent thickness. The equations of flow in such a subsonic jet are then nonlinear, but all fluctuations in the supersonic jet remain small so that the fundamental Euler equations can be linearized. The corresponding equation for the fluctuation velocity potential, in dimensionless form with $\beta^2 = M_1^2 - 1$, is solved for boundary conditions of impermeability at the upper channel wall and at the surface separating the two jets. A solution is obtained with the aid of the Bernoulli integral for the pressure in the supersonic jet. The number $\Delta = 2\beta H/1$ (H- height of channel, $1 = d_\infty/\tau$, d_∞- quiescent thickness of subsonic jet, small parameter $\tau = 1/2\beta\rho_2 v_2^2/\rho_1 v_1^2$) is the only similarity parameter in the solution and $\Delta>1$ corresponds to a supercritical flow of the two interacting jets. As a special case of such a flow is considered one with self-induced perturbations in a channel with a straight lower wall. The amplitude of these perturbations is found to decrease to zero as transition to subcritical interaction occurs with $\Delta\rightarrow 1$. Figures 4; references 9: 7 Russian, 2 Western.

REFLECTION OF PLANE SHOCK WAVE BY BODY WITH CONCAVE SURFACE

[Article by M.A. Ibragim, A.O. Serov, L.S. Shtemenko, and F.V. Shugayev]

[Abstract] An experimental study was made of the transient flow pattern in a plane shock wave reflected by bodies with cylindrical concave front surfaces of various depths, with either air or Freon-14 as the gaseous medium. Models of two kinds were used, one kind as wide as the shock tube with an almost two-dimensional flow and one kind narrower than the shock tube with a square flow cross-section. While the Mach number of the

incident shock wave was varied over the N_M = 2-4.5 range, the velocity of the shock wave along the shock tube was measured with built-in piezo-electric probes. Visualization of the flow by the shadow method with a Q-switched single-mode ruby pulse laser as light source has revealed forma-tion of vortices at the corners and inside, their width increasing in a deeper concavity. It has also revealed an intricate interaction of the main shock wave and transverse shock waves, which results in formation of several separating surfaces, as well as formation of a counterflowing jet inside the concavity. The flow pattern of air is found to depend much less on the recess depth than does the flow pattern of Freon-14, with the flow in the latter case becoming steady after a transient period much longer with than without a concave surface in the shock tube. The authors thank V.I. Ivanov for computations. Figures 5; references 8: 7 Russian, 1 Western.

EXPERIMENTAL STUDIES OF SHEAR MODULUS OF FREELY REINFORCED FILLER

[Article by V.N. Kobelev, doctor of technical sciences, Professor M.M.
Batdalov, candidate of technical sciences, docent; O.M. Ustarkhanov,
engineer; and V.N. Novikov, engineer]

[Abstract] Glass fiber mats can be used as a filler in flexible or rigid
multilayer construction elements; a filler of this kind is called freely
reinforced. Hitherto data have been lacking on the dependence of the
properties of a freely reinforced filler on its density. The procedure
and results are given of a study on determination of the shear modulus
of a lengthwise and randomly-positioned freely reinforced filler, i.e., a
glass fiber mat. The shear modulus was determined from torsion tests of
cylindrical models. Models with the fibers arranged lengthwise were in
the form of a glass fiber cylinder 49 mm in diameter and 125 mm long.
Models with a random arrangement of fibers were formed from two polished
cylinders of different diameters which were moved in relation to one
another to vary the space occupied by the filler. Plates were fastened
to the cylinder's ends by means of epoxy cement. The experimental apparatus
consisted of two posts on which a shaft was installed by means of bearings.
The shaft was rigidly connected to the model, and at the other end the
model moved freely along the axis of the shaft on guides. A load created
by a set of weights was transmitted by means of a cable to the shaft and
from it to the model being tested. When the models were loaded they
were twisted and a neck formed at the center of the model. The shear
modulus was measured up to the instant of the formation of the neck with
a density equal to that of glass. In processing the experimental data the
reduced density of the models was used, in which the change in density
caused by twisting was taken into account. Accordingly, the reduced
shear modulus was found. The results demonstrated that with the fibers
oriented lengthwise the reduced shear modulus increased insignificantly
with an increase in the density of the models. With the fibers oriented
randomly the shear modulus changed more quickly. On the whole the shear
modulus was higher with the fibers oriented chaotically, than longitudinally.
With a random arrangement, individual fibers are oriented along the

direction of application of the load and are thus subjected to tension.
The results are interesting from the viewpoint of designing structures in
which the strength and rigidity of construction elements depend directly
on the material's shear strength. References: 2 Russian.

8831/9835
CSO: 1861/226

TOWARD A THEORY OF REGULAR PIECEWISE-UNIFORM STRUCTURES WITH PIEZOCERAMIC
MATRIX

[Article by O.A. Ivanenko and L.A. Filshtinskiy]

[Abstract] A piecewise-isotropic piezoelectric medium reinforced by a
system of identical anisotropic fibers not bounded along the y axis that
is referred to the crystallophysical xyz axes is investigated. A model
is constructed of the regular piezoceramic medium assuming that the
physical/mechanical properties of all the fibers are the same and have a
plane of elastic symmetry perpendicular to the y axis, and that the
conditions of electrical and mechanical contact between the fiber and the
matrix are ideal. The state equations of macromodel of the structure are
derived from the average mechanical and electrical values. An algorithm
is derived and implemented numerically. The averaged elastic, electrical,
and piezoelectric properties of the medium are analyzed as a function of
the cellular microstructure. A composition material with a PZT-5 piezo-
ceramic matrix is analyzed as an example. Figures 2; references:
11 Russian.

6900/9835
CSO: 1861/267

TOWARD A THEORY OF PIEZOELECTRIC SHELLS

[Article by Le Khan Chau]

[Abstract] Variational principles of the theory of piezoelectricity are
investigated. A minimax principle for the application of variational-asymptotic

analysis in the problem of equilibrium in the piezoelectric shells is investigated. The electrical enthalpy functional is analyzed asymptotically. The connection between three-dimensional and two-dimensional electroelastic stressed states is investigated. References 18: 13 Russian, 5 Western.

CLASSIFICATION OF FREE OSCILLATIONS OF PIEZOCERAMIC SHELLS

[Article by N.N. Rogacheva]

[Abstract] Free oscillations of piezoceramic shells with arbitrary form polarized along a family of coordinate lines of the mid-surface are investigated. Asymptotic analysis indicates that free oscillations of piezoceramic shells with pre-polarization along $\alpha 2$-lines with non-electrodyne face surfaces can be divided into quasi-transverse with small variability, quasi-transverse with large variability, quasiperiodic with variability $t=1/2$, quasi-tangential, and superlow-frequency Rayleigh type, each of which is described by the corresponding system of equations. References: 6 Russian.

VIBRATIONS OF THIN ELASTIC LAYER IN CONTACT WITH SOFT ELASTIC BODY

[Article by P.Ye. Tovstik]

[Abstract] A thin elastic layer in contact with a soft elastic body is considered, its state of stress and strain being characterized by a high degree of variability and its vibration frequencies being limited by an upper cutoff. Approximate expressions are formulated which relate contact stresses to layer displacements so that vibrations of the layer can be analyzed without solution of the three-dimensional elasticity problem for the soft body and the thin layer can be regarded as being under an

additional load which represents the elasticity and the apparent mass of
the soft body. The soft body is first assumed to constitute an elastic
half-space and then allowed to have an arbitrary shape. As a general case
is considered a thin layer or flat shell of uniform thickness smaller than
the characteristic dimension of the soft body and its low-frequency quasi-
transverse or circumferential vibrations, more specifically those of a
flat shell rectangular in the plan view on hing supports, of a circular
cylindrical shell on hing supports, and of a truncated conical shell. In
addition are also considered high-frequency longitudinal vibrations of a
thin cylindrical shell. References: 3 Russian.

2415/9835
CSO: 1861/270

STRUCTURING PRINCIPAL INTEGRAL IN PROBLEM OF STABILITY LOSS NEAR EDGE OF
CONVEX SHELLS

[Article by A.L. Mayboroda]

[Abstract] An elastic convex shell in a zero-moment state of stress is
considered and the problem of its loss of stability is treated in the
linear approximation. The weakest spot is assumed to be close to or at one
edge so that homogeneous boundary conditions must be satisfied at this edge,
no boundary conditions having to be satisfied at the outer edge where the
instability has completely decayed. Solution of the corresponding system of
equations for flat shells requires appropriate structuring of the principal
integral as well as of the edge-effect integrals and then satisfying the
boundary conditions at that edge. The principal integral is accordingly
structured in the form $\{w,\emptyset\} = e^{iz} \{w_1(\alpha_k,\mu), w_2(\alpha_k,\mu)\}$ with $z = \mu^{-1}(p_1^0 n + p_2^0 s)$,
and $w_0 = e^{i(p_1^0 n + p_2^0 s + \frac{1}{2} s^2)\mu^{-1}} [U(kh\mu^{-2/3} + \gamma)(u_0 + \mu^{1/6} u_1 + \ldots) + k\mu^{1/3} U'(kh\mu^{-2/3} + \gamma)(v_2 + \mu^{1/6} v_3 + \ldots)]$. References: 2 Russian.

2415/9835
CSO: 1861/270

METHOD OF DETERMINING SURFACE CONCENTRATION ON EXTERNAL SURFACE OF Cu-Ni SINGLE CRYSTALS

[Article by B.S. Ashavskiy, Moscow Institute of Steel and Alloys, and V.Yu. Demin, Institute of Physical Chemistry, USSR Academy of Sciences, Moscow]

[Abstract] A method is proposed for experimentally determining, with the aid of Auger electron spectroscopy, the isotherm of surface concentration in oriented solid-solution alloy single crystals. The method requires only one specimen, rather than many specimens of different compositions otherwise required. It involves two successive annealing processes, diffusion annealing to establish a volume concentration gradient and adsorption annealing to facilitate equilibrium adsorption. The method was successfully applied to Cu-Ni alloying. On one lateral surface of a thin square Ni single crystal with given crystallographic orientation of the upper surface was electrolytically deposited a 100 μm thick Cu layer. High-temperature diffusion annealing at 1050°C for 150 h allowed copper to diffuse 300 μm deep along the upper surface, with a very low concentration gradient of approximately $1.6 \cdot 10^{-3}$ mole/ μm. The specimen was then mechanically polished and degreased, prior to purification "in situ" inside the analyzer chamber of a VG Scientific Ltd "Escalab-5" electron spectrometer. Absence of surface oxidation during the first heat treatment was confirmed by absence of CuO and NiO lines in the Auger spectrum. After an upper surface layer of the nickel crystal had been removed for measurement of the Cu concentration profile in the direction of diffusion, adsorption equilibrium between surface and bulk was subsequently established by a low-temperature second annealing process at 500°C for only 1.5 h, so as not to alter the already established volume distribution of copper. The main problem in this method is the effect of diffusion on the reliability of concentration measurements. An analysis based on the second Fick equation and the equation of material balance, with the upper surface layer treated as an isotropic plate and with numerical estimates of relevant process parameters, indicates that under given conditions the surface concentration will have reached its equilibrium level for reliable measurement. Figures 2; references 8: 1 Russian, 7 Western (3 in Russian translation).

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